Effect of calcium, boron and zinc on growth, flowering and bulb production of Tulip (*Tulipa gesneriana* L.) cv. Apeldoorn

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(2007-175-D)

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THESIS

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DEDICATED TO
MY ADORABLE
PARENTS

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Shalimar Campus, Srinagar
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Certificate – I

This is to certify that the thesis entitled **"Effect of calcium, boron and zinc on growth, flowering and bulb production of Tulip (*Tulipa gesneriana* L.) cv. Apeldoorn"** submitted in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy in Horticulture (Floriculture & Landscape Architecture)**, to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, is a record of bonafide research work carried out by **Muzamil Rasool (Regd. No. 2007-175-D)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that any help or information received during the course of investigation have duly been acknowledged.

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Certificate – II

We, the members of the Advisory committee of **Muzamil Rasool (Regd. No. 2007-175-D)**, a candidate for the degree of **Doctor of Philosophy in Horticulture (Floriculture & Landscape Architecture)**, have gone through the manuscript of the thesis entitled, **"Effect of calcium, boron and zinc on growth, flowering and bulb production of Tulip (*Tulipa gesneriana* L.) cv. Apeldoorn"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of degree.

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This is to certify that the thesis, **"Effect of calcium, boron and zinc on growth, flowering and bulb production of Tulip (*Tulipa gesneriana* L.) cv. Apeldoorn"** submitted by **Muzamil Rasool (Regd. No. 2007-175-D)** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy in Horticulture (Floriculture & Landscape Architecture)** was examined and approved by her Advisory Committee and external examiner on ………………..

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ABSTRACT

The study entitled "Effect of Ca, B and Zn on growth, flowering and bulb production of Tulip (*Tulipa gesneriana* L.) cv. Apeldoorn" was carried out in the field at the Research Farm, Division of Floriculture, Medicinal and Aromatic Plants, SKUAST-K, Shalimar during 2008-2009 & 2009-2010.The experiment was laid out in factorial RBD with three levels of Calcium (0.00, 5.00 and 10.00 kg ha^{-1}), three levels of Boron (0.00, 0.50 and 1.00 kg ha^{-1}) and two levels of Zinc (0.00, 8.00 kg ha^{-1}) in 18 different combinations with three replications. The study revealed that Ca at 10.00 kg ha^{-1} recording maximum bulb sprouting per cent (99.89), plant height (37.10 cm), wrapper leaf area (232.35 cm^2), leaf Boron (27.52 ppm), Ca (5.52 %) and Zn content (26.77 mg g^{-1}) and minimized malformed leaves per cent (0.11) and maximum number of bulbs (57.27), weight of bulbs (783.41 g) and highest bulb production ratio of (1.43).

Moreover, minimum days to flower opening (7.02) and maximum vase life (7.85 day) was recorded in vase by 10.00 kg of Ca ha^{-1}.

Boron at 1.00 kg ha^{-1} also had a significant influence on bulb sprouting per cent (99.09), plant height (36.03 cm), wrapper leaf area (205.27 cm^2), leaf B (25.77ppm), Ca (5.13%) and Zn content (26.38 mg g^{-1}) and minimized malformed leaves per cent (0.50), maximum number of bulbs (54.02), weight of bulbs (765.99 g) and bulb production ratio (1.35) were highest during both the years.

It was found that with 1.00 kg B ha^{-1} was superior in recording minimum days to flower opening (7.36) and maximum vase life of 7.77 days.

Zn at 8.00 kg ha^{-1} was found significant in increasing bulb sprouting per cent (98.60), plant height (35.47 cm), wrapper leaf area (189.09 cm^2), leaf boron (25.21ppm), Calcium (5.00%) and Zinc content (26.28 mg g^{-1}) and minimized malformed leaves per cent (0.59). Maximum number of bulbs (53.38), weight of bulbs (757.39 g) and bulb production ratio (1.33) during both the years.

Better results were obtained in respect of earliness in days to flower opening (7.42) and maximum vase life (7.65 day) by the application of Zn 8.00 kg ha^{-1}.

Interaction effect of Ca and B at (10.00) & (1.00) kg ha^{-1} recorded maximum plant height (38.03 cm), wrapper leaf area (179.47 cm^2), leaf B (28.19 ppm), leaf Ca (5.79%) and Zn content (26.92 mg g^{-1}) and minimum malformed leaves per cent (0.00) and highest bulb production ratio (1.49). The same treatment recorded minimum days to flower opening (7.00) and maximum vase life of 7.96 day.

The interaction between Ca (10.00 kg ha^{-1}) and Zn (8.00 kg ha^{-1}) recorded maximum plant height (37.26 cm), wrapper leaf area (241.37 cm^2), leaf B (27.74 ppm), leaf Ca (5.60 %) and Zn (26.80 mg g^{-1}) and minimum mal formed leaves per cent (0.05). Highest bulb production ratio (1.49) and maximum vase life of 7.86 days were recorded under the same treatment combination. Boron (1.00 kg ha^{-1}) and Zinc (8.00 kg ha^{-1}) interaction also exhibit better results.

Combined effect of Ca, B and Zn on growth, flowering, bulb production and vase life of tulip during both the years was found superior in increasing plant height (38.18 cm), number of leaves per plant (4.84), wrapper leaf area (179.86 cm^2), leaf chlorophyll content (0.56 mg g^{-1}), leaf boron content (28.30 ppm), leaf Ca content (5.85%) and leaf Zn content (26.96 mg g^{-1}). The highest petal membrane stability (56.25%) and minimum number of days to appearance of floral bud (99.38), days to color break (7.13) and days to flower opening (5.00) was recorded significantly by treatment combination of Ca (10.00), B (1.00) and Zn (8.00) kg ha^{-1}.

Maximum flower diameter (8.96 cm), scape length (25.88 cm) and scape thickness (6.84 mm) was found with C_2 B_2 Z_1 treatment combination. While, minimum was with control. Maximum number of bulbs (61.66), weight of bulbs (790 g m^{-2}) and bulb production ratio (1.54) during both the years was with the highest dose of Ca, B and Zn. Moreover, earliness in flowering (7.00 day), maximum fresh weight (13.88 %), maximum water uptake (18.39 g/scape) and minimum water loss (10.38 g/scape) and maximum vase life (8.00 day) were recorded with highest dose of Ca, B and Zn. Maximum net return Rs. 7569100 with a cost benefit ratio of 1.47 was obtained with Ca (10.00 kg ha^{-1}), B (1.00 kg ha^{-1}) and Zn (8.00 kg ha^{-1}) treatment combination.

Key words: Ca, B, Zn, Tulip, Physiological behavior, Flower scape, Bulbs.

Signature of Student — Signature of Major Advisor

Dated:____________ — Dated:_________________

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"IN THE NAME OF ALLAH THE MOST BENEFICIENT, THE MOST COMPASSIONATE"

''Allahumma-aslih lee deeni-al-lazi huwa ismatu amri wa asleh lee dunyayallati feeha ma'ashi wa asleh lee aakhiratallati feeha ma'adi waj alil hayata ziyadatal-lee fee kulli khairin waj alil mauta raahatal-lee min kulle sharrin.''

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Muzamil Rasool

Place: Shalimar, Srinagar

Dated:

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CHAPTER – 1

INTRODUCTION

Floriculture is increasingly regarded as a viable diversification from the traditional field crops due to increased per unit returns and the increasing habit of "saying it with flowers" during all the occasions. Globally, more than 140 countries are involved in cultivation of floricultural crops. India is the second largest flower grower after China. The domestic industry is growing at an annual growth rate of 10 to 20 per cent. The area under flower production in India is around 1.61 lakh hectares concentrated mostly in Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra and West Bengal with a production of 8.70 lakh metric tonnes of loose and 4.30 million numbers of cut flowers. The floriculture exports have gone upto Rs. 350 crore during 2007-08 from a meagre amount of Rs. 14.80 crore in 1991-92 (Anonymous, 2008).

Tulip (*Tulipa gesneriana* L.) is a monocotyledonae belongs to family Lilaceae and is believed to be the native of Mediterranean and China but the natural origin of garden tulips seems to be lost, though many workers believe that it is derived from Gesneriana (Hall, 1940). Tulip is mainly Asiatic centered with hilly countries of Asia minor, the Southern Cancasus, Turkistan and Bukhara petering out in northeast Asia. The richest gene centre is in the north western spurs of Himalayas, where there are about 50 species out of total of 100-150 species (Hoog, 1973; De Hertogh *et al*., 1983; Rees, 1972, 1992). Diversification took place from the region of Tien-Shan and Pami-Alai to the north and northeast (Siberia, Mongolia and China), South Cashmere in India and West to Afghanistan, Iran, the Cancasus and Turkey (Bailey and Bailey, 1976; Rees, 1985; Le-Nard and De-Hertogh, 1993).

Among all the ornamental bulbous plants, tulip represents the largest geophyte crop worldwide. The species are perennials from bulbs, the tunicate bulbs are often produced on the ends of stolons and covered with glabrous to variously hairy papery coverings. The species include short low growing plants to tall upright plants, growing from 10 to 70 cm tall. Plants typically having 2 to 6 leaves, with some species up to 12 leaves. The cauline foliage is strap-shaped, waxy-coated, usually light to medium green and alternately arranged. The blades are somewhat fleshy and linear to oblong in shape. The large flowers are produced on scapes normally lacking bracts. Typically species have one flower per stem but a few species have up to four flowers. The colourful and attractive cup shaped flowers have three petals and three sepals, which are most often, termed tepals because they are nearly identical. The six petaloid tepals are often marked near the bases with darker markings. The flowers have six basifixed, distinct stamens with filaments shorter than the tepals and the stigmas are districtly 3-lobed. The ovaries are superior with three chambers. The 3 angled fruits are leathery textured capsules, ellipsoid to subglobose in shape, containing numerous flat disc-shaped seeds in two rows per locule.

Tulip is the first ranking ornamental bulbous plant in the world and has gained popularity due to its beauty and economic value. Tulips are excellent for cut flowers, garden display and pot culture. It is the top most flowering geophytes of the Netherlands and occupies second position among top ten cut flowers in global floriculture trade (Jhon *et al.*, 2007). The Netherlands is the centre for world bulb production. Production of tulip takes place in some 15 countries world-wide, with the largest production area in the Netherlands with 10,800 hectares (88%). The next 5 main countries are Japan (300 hectares, 2.5%), France (293 hectares, 2.4%), Poland (200 hectares, 1.6%), Germany (155 hectares, 1.3%) and New Zealand (122 hectares, 1%). The Netherlands produces 4.32 billion tulip bulbs, of which 2.3 billion (53%) are used as the starting material for the cultivation of cut flowers. No fewer than 1.3 billion of these (57%) are grown in the Netherlands as cut flowers (Buschman, 2010).

Tulips thrive well in temperate regions of Jammu and Kashmir, Himachal Pradesh and other similar hilly regions. The bulbs can grow best under the temperature ranging between 5-10 and 20-25 □C. Large varieties of brilliant shades can turn its cultivation into a great bulb growing industry (Desh-Raj, 1999).

However, the quality production of bulbs and cut tulips are prone to many disorders like stem topple, bud abortion of varying severity, caused by various agencies like water logging, drought, changes in temperature. Application of Ca, B, Zn etc have been reported to improve the plant growth and flower quality of bulbous ornamentals (Nelson and Niedziela, 1998b; Khan, 2000; Kumar *et al.*, 2001 and Nath and Biswas, 2002). Calcium has an important role in the structure and permeability of cell membranes. Claims have been made that topple disorder of tulips is due to Ca deficiency (Rasmussen, 1972). Boron plays an essential role in the development and growth of new cells, cell division and cell wall formation and integrity. Boron deficiency causes symptoms that result from plant cells that are not properly “stuck together”. Zinc is associated with the formation of tryptophane, the precursor of auxin (IAA).

Since very meager work has been conducted on tulip in this country, the present investigation was, therfore, planned to be undertaken with the following objectives:

- To ascertain the effect of Ca, B and Zn on growth and physiological characters of tulip.
- To ascertain the effect of Ca, B and Zn on flowering and bulb production.
- To study the effect of Ca, B and Zn on post harvest behaviour of cut tulip.
- To determine the optimum level of Ca, B and Zn for quality flower and bulb production.
- To find out the relative economics.

CHAPTER – 2

REVIEW OF LITERATURE

The literature relating to Ca, B and Zn on growth, physiological characters, bulb production and post harvest quality of tulips is briefly reviewed here under:

2.1 Effect of calcium on biometric characters

Rees *et al*. (1972) found the glassy water-soaked area in the top internode just below the flower, shrinks and leading to topple. The internodes contain less calcium, application of calcium nitrate 2-3 times a week at 2lb (908 g) /100 gal (380 l) can control this problem. They also reported that Dutch iris is prone to stem topple caused by calcium deficiency.

Rasmussen *et al.* (1972) reported the effects of storage temperature and nutrition on topple disease of forced tulips; the malady was due to Ca deficiency. The application of 100 g calcium nitrate in 10 litre water was an excellent preventive measure.

Boon-J-Van-der *et al.* (1974) studied that the forcing tulip cv. Lustige Witwe using 0, 2, 4, 8 or 10 kg Emkal (53.2 % $CaCO_3$ m^{-3}) in addition to NPK and trace elements. Plants lined at lower levels were browner than where higher levels were used. Optimum liming was 2 to 4 kg m^{-3} for forcing.

Rasmussen *et al.* (1974) observed that application of calcium nitrate and urea as a nitrogen source on tulips at 69.8 kg N ha^{-1}, increased total plant yield and the number of top grade bulbs suitable for forcing.

Munk *et al.* (1975) reported preharvest conditions on the quality of cut tulip flowers, including shortened stems, flower bud-blast, greening and “topple” can be regarded partly as after-effects and partly direct effects of environmental conditions during bulb storage, transport and growth during forcing.

De Hertogh *et al*. (1978) found that Ca $(NO_3)_2$ fertilizer decreased flower abortions, flower topple and increased flower size and fresh weight of tulips.

Hoogeterp *et al.* (1979) observed that bulbs with a low N content were more susceptible to topple disorder, but was not related to bulb Ca content. The disorder was also associated with poor rooting. Calcium requirement of flower primordial during the development has been found to be very high.

In Hippeastrum, the bent neck was associated with low Ca, rather high K content (Carrow and Rober, 1979).

Calcium is relatively immobile in the plant, its continuous supply through soil is very essential in order to prevent blindness in tulips (Klougart *et al.*, 1980).

Klougart *et al.* (1980) described that Apeldoorn tulip bulbs could be successfully forced into flower in water containing Ca ions preferably Ca $(NO_3)_2$.

Le Nard (1993) concluded that a complete nutrient solution containing a fertilizer (13-4-19) produced 40 per cent of 'topples' in 'Apeldoorn' tulips compared with no 'topple' in 50 ppm of calcium nitrate solution. He further reported that nitrate form, was found to be the best source of calcium while sulphate form showed very poor response and suggested a minimum calcium uptake of 11 mg per plant for obtaining the best quality flowers.

Narayana and Nage (1990) found that calcium sulphate has a significant influence on vase life of gladiolus. It has also been reported that Asters top dressed with calcium and Fe-EDDHA, reduced Fusarium wilt (Skrzypczak and Orlikowski, 1996). Calcium at 12 kg ha^{-1} increased bulb production in tulips (Bakker, 1991).

Calcium applied at a dose of 12.5 m mol/litre of substratum significantly increased the number of healthy bulbs and their yield in tulip (Orlikowski *et al*., 1997).

Nelson and Niedziela (1998a) observed that topple was prevented by Ca $(NO_3)_2$ in a low temperature regime (21^{o}C days and 18^{o}C night). A rate of 0.18 mg ancymidol/pot + 5 mM Ca $(NO_3)_2$ prevents Ca deficiency symptoms in tulips.

Nelson and Niedziela (1998b) observed that *Tulipa gesneriana* forced hydroponically in distilled water developed Ca deficiency symptoms, including topple and flower bud abortion. Prevention of Ca deficiency and uptake of Ca was greater when Ca was supplied in the NO_3 form. A 5mM solution of Ca (NO_3), prevented Ca deficiency during all forcing periods.

Wawrzynczak and Goszczynska (2000) reported that the vase life of tulips was improved by using 0.1 mM GA_3, 0.4 mM BA and 2mM Ca $(NO_3)_2$.

Lee *et al.* (2001) observed that tulips with physiological disorders showed abnormal characteristics in height, leaf and peduncle and petal growth. The growth disorder appeared to be a stem topple caused by temperature, humidity and inhibition of Ca absorption in the green house conditions.

Nelson *et al.* (2003) reported that *Tulipa gesneriana* forced hydroponically in distilled water developed Ca deficiency including topple and flower bud abortion. Uptake of Ca was greater when Ca supplied in the NO_3 form rather than as Cl^- or SO_4^{2-}. They further observed that 2.5 m M Ca $(NO_3)_2$ solution prevented Ca deficiency symptoms in tulips.

An increase in spike length, number of florets per spike, width of floret, size of corm and weight of corms were increased in gladiolus under 0.5 per cent $CaSO_4$ (Kumar *et al*., 2003).

Unal and Cavusoglu (2005) recorded maximum plant height in saffron with the application of calcium ammonium nitrate.

Applicating calcium nitrate at 1% at monthly interval recorded less number of days for flowering and highest flowering per centage in gladiolus (Kumar *et al*., 2006) and further reported that application of salicylic acid (100 ppm) and calcium nitrate (1%) caused flower induction in gladiolus cormels, and recorded less number of days for flowering and highest flowering per centage.

Naik *et al.* (2007) observed that the water content of orchids showed a positive correlation with P, K, Ca and Mg and negative correlation with N and S content and were significantly influenced by K, Ca and Mg content at the level of 41.74, 65.67 and 21.44 per cent.

Choi *et al*. (2010) investigate that fertilizer solution 3.0, 4.5 and 6.0 mM resulted in increased dry weight of Oriental hybrid lily 'Casa Blanca', the tissue Ca contents were 2.8, 2.9 and 3.0%, respectively. Application of 0, 3.0, 4.5 and 6.0 mM Ca in fertilizer solution resulted in 189.9, 225.3, 337.9 and 285.0 mg L^{-1}, respectively, of soil Ca concentrations at the harvesting stage.

2.2 Effect of boron on biometric characters of tulip

Ikarashi and Baba (1977) reported that the absence of flower pigments and a transverse break in the flower stem disorders were caused by boron deficiency in tulips.

Rasmussen *et al.* (1975) reported widespread leaf tip burn in forced tulips cv. Rose Copland. The cause could be excess boron. Various rates of B as borax or solubor were applied to tulips, tip burn symptoms were induced with 5.4 kg B/ha as 15 kg borax plus 2 sprays of 8 kg solubor. Disappearance of anthocyanin in the flowers (Ironuke), transverse fracturing of the stem (kubiore), stunted stem and abnormal root were observed mainly due to B deficiency (Ikarashi and Baba, 1971).

Rose cv. Celebration produced best quality flowers and gave high yield when treated with boron at 1000 ppm (Maharana and Pradhan, 1977).

According to Peterburgskii and Lyashko (1977) the pre-planting treatment of boron induced earlier emergence and a more vigorous start of growth in tulips. They further reported an application of slow release boron produced remarkable increase in yield of tulips.

Muller *et al.* (1984) described several symptoms of boron deficiency in tulips particularly stem cracking, flower splitting, rough stem base and fading of the flower color.

Valk and Brulin (1989) reported that a low soil content of B was responsible for a loss in quality of tulip bulbs. Increasing organic matter in the soil without adding trace elements adversely affected the bulb yield, bulb contents of Cu, B and dry matter.

Sidhu and Tiwari (1993) reported an increase in the bulb yield of onion, when 1 ppm Cu + 3 ppm Zn + 0.5 ppm B + 100 ppm Fe was applied.

Foliar application of B in combination with 300 ppm P_2O_5 increased the number of florets spike^{-1} and the per centage of eugenol and farnesol components in the essential oil (Mostafa *et al.*, 1996).

Lee and Choi (1998) reported that tulip cv. Apeldoorn exhibited reduced growth (shorter lead length, narrow petal widths and decreased aerial dry weight) with higher concentration of B (> 0.4 %). Moreover, the chlorophyll content of leaves, anthocyanin content of flowers was decreased and colour changes in flowers were also observed.

According to Khan (2000) that B at 0.2% stumilated maximum plant height, stem diameter, leaf area and branching in dahlia.

Maximum plant height, number of leaves and width of leaves was increased with 100 ppm boron. Also boron had good response to the reproductive characters of the tuberose (Nath and Biswas, 2002).

Length of leaf and floret, spike length, number of florets per spike, width of floret, size of corm and height of corms in gladiolus were increased under 0.2 per cent borax (Kumar *et al*., 2003).

Kumar *et al.* (2003) observed that spray of borax, $CaSO_4$ and $ZnSO_4$ at 0.2, 0.5 and 0.75 per cent induced early flowering and maximum number of corms and corm weight in gladiolus.

Halder *et al.* (2007) reported that interaction effect of B (2.0 kg ha^{-1}) and Zn (4.2 kg ha^{-1}) significantly contributed to the yield of individual corm weight (26.07 g and 27.5 g) and number of cormels (9.78 and 14.43) and weight of cormels $plant^{-1}$ (31.94 g and 51.67 g) in gladiolus.

2.3 Effect of zinc on biometric characters of tulip

Maharana and Pradhan (1977) reported that rose cv. Celebration produced best quality flowers and gave highest yield when it was treated with Fe, Mn, B, Cu, Zn and Mn at 1000, 700, 1000, 8000, 5000 and 60 ppm, respectively.

Foliar application of Zn produced the earliest and most profuse flowering in tulips (Peterburgskii and Lyashko, 1977).

Emino *et al*. (1980) reported that zinc application on shrubs increased the growth and plant quality. Omran *et al*. (1984) reported an increase in bulb weight, leaf number and length of bulb in onion when the foliar application of 200 ppm/AA and 0.05 per cent $ZnSO_4$ were given.

Dwivedi and Dwivedi (1991) found that 20 kg zinc sulphate in combination with copper and boron recorded the highest potato tuber yield of 14 tonnes per hectare.

Tiwari and Dwivedi (1991) reported that the application of 5 kg zinc per hectare increased tuber yield by 21.9, 7.5 and 0.7 per cent in low, medium and high zinc status soils respectively and zinc concentration in potato tuber ranged from 22.3 ppm with application to low zinc status soils to 10.2 ppm.

Foliar spray of micro-nutrients with $ZnSO_4$ on *Polianthes tuberosa* cv. Single at 60 days interval at 0.25 per cent resulted in highest number of leaves per clump and flower spikes/plot (Barman and Pal, 1993).

An increase in the bulb yield of onion was reported when 3 ppm Zn was applied (Sidhu and Tiwari 1993).

Khan (2000) observed that Zn at 0.4 per cent stimulated maximum plant height, stem diameter, number of leaves, leaf area and branching in Dahlia.

Spike length, number of florets, weight of spike and size of florets were significantly increased with $FeSO_4$ + $ZnSO_4$ each at 0.2 per cent while longest duration of flowering was observed under 0.4 per cent $FeSO_4$ + 0.2 per cent $ZnSO_4$ and maximum number of corms was noted under 0.2 per cent $ZnSO_4$ in gladiolus (Kumar and Arora, 2000).

Prabhat and Arora (2000) reported that the application of 0.2 per cent $FeSO_4$ + 0.2 per cent $ZnSO_4$ increased spike length, number of florets, weight of spike and size of florets. Flower duration was longest with 0.4 per cent $FeSO_4$ + 0.2 per cent $ZnSO_4$.

Singh *et al*. (2000) studied the effect of various levels of $ZnSO_4$ (0, 10 and 20 kg ha^{-1}) on the corms and cormlets production of gladiolus. Application of highest level of $ZnSO_4$ caused the highest increase in weight of corms/plant, diameter of corms and average weight of corms.

Soumen *et al*. (2000) observed that $ZnSO_4$ at 500 ppm exhibited good performance for enhancing the vase life of gladiolus.

Kumar *et al*. (2001) reported that foliar application of Zn in the form of $ZnSO_4$ (1000 ppm) showed better results in respect to growth, flowering and other yield parameters and quality parameters of gladiolus cv. Mirela.

Foliar application of Zn at 1000 ppm increased the growth, flowering and yield attributes and quality parameters of *Gladiolus grandriflorus* (Mukesh *et al.* 2001).

The application of 15 kg Zn ha^{-1} gave the best values for plant height, number of leaves per clump, number of bulbs per clump, number of nots per clump, root length in *Gladiolus grandiflorus* (Mukesh *et al.*, 2001).

Spraying $ZnSO_4$ at 0.75 per cent induced early flowering, increased number of corms and corm weight in gladiolus (Rajiv *et al.* 2003).

Katiyar *et al.* (2005) observed that Zn and Cu at 0.2 per cent increased plant height and mixture of both sprays increased the vegetative growth and enhanced the floral characteristics in gladiolus.

$FeSO_4$ and $ZnSO_4$ at 0.5 per cent concentration significantly enhanced iron and zinc content in the leaves of gladiolus cv. Trader Horn at 3rd and 6th leaf stage (Pratap *et al.* 2005).

Khan *et al.* (2006) studied the effect of two levels of zinc (0 and 5 kg ha^{-1}) on tulip. Application of Zn at 5 kg ha^{-1} was found most suitable dose for obtaining better growth, quality flower and bulb production.

Bala *et al*. (2007) in their experiment on gladiolus studied the effect of preharvest sprays of $ZnSO_4$ (0, 0.5 and 1 %) on flowering, flower quality and vase life. Flowering was delayed with the increased concentration of $ZnSO_4$. The maximum fresh weight, minimum water loss to uptake ratio, maximum vase life and minimum number of florets opened per day was recorded due to preharvest sprays of $ZnSO_4$ 0.5 per cent. Enhanced Zn content in the leaves was also recorded in gladiolus by spraying with $ZnSO_4$ at 0.5 per cent.

Halder *et al.* (2007) reported that Zn 4.2 kg ha^{-1} significantly increased corm weight (27.5 g), number of cormels (14.43) and weight of cormels $plant^{-1}$ (51.67 g) in gladiolus.

CHAPTER – 3

MATERIALS AND METHODS

The present investigations entitled "Effect of calcium, boron and zinc on growth, flowering and bulb production of tulip (*Tulipa gesneriana* L.) cv. Apeldoorn" were carried out in the experimental blocks of Division of Floriculture, Medicinal and Aromatic Plants, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar during two consecutive seasons (2008-09 and 2009-10).

3.1 Geographical features

Srinagar, the summer capital of Jammu and Kashmir State is situated between $34^{o}5'$ to $34^{o}7'$ north latitude and $74^{o}8'$ to $74^{o}9'$ east longitude at an altitude of about 1575 m above mean sea level. It is flanked on the southeast and northeast by the lofty Himalayan ranges. At the base of these ranged towards the north is the University Campus, Shalimar about 15 km from main city.

3.2 Climate

The climate, in general, is temperate-cum-Mediterranean and of continental type. Winter is severe extending from middle of December to early March, when the temperature sometimes goes below freezing point and whole of the valley remains snowbound. June to August were the hottest months during the period of investigation with an average temperature shooting up to $28.7^{o}C$. The average recorded annual precipitation was 944.6 mm (average over past thirty years) with more than 80 per cent being received from western disturbances. The meteorological data pertaining to the period of investigation are presented in Appendix-I.

3.3 Soil characteristics

Soil of the experimental plot was silty clay loam in texture possessing good water holding capacity.

3.4 Experimental details

The details are given as under:

Treatments

1) Calcium (Ca) in the form of calcium nitrate: 03 levels

   i) 0 kg ha^{-1}

   ii) 5.00 kg ha^{-1}

   iii) 10.00 kg ha^{-1}

2) Boron (B) in the form of borax : 03 levels

   i) 0 kg ha^{-1}

   ii) 0.50 kg ha^{-1}

   iii) 1.00 kg ha^{-1}

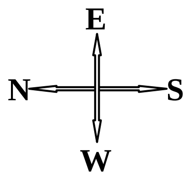
3) Zinc (Zn) in the form of zinc sulphate: 02 levels

   i) 0 kg ha^{-1}

   ii) 8.00 kg ha^{-1}

Design	:	Factorial RBD
Replications	:	03
Number of treatment combinations	:	18
Plot size	:	1 m x 1 m
Planting density	:	40 bulbs per plot

3.5 Layout plan of the experiment



R1		Sub- Irrigation Channel	R2		Sub-Path	R3		Sub- Irrigation Channel
T_{17}	$C_2B_2Z_0$		T_{15}	$C_0B_0Z_1$		T_4	$C_0B_1Z_1$	
T_4	$C_0B_1Z_1$		T_{10}	$C_1B_1Z_1$		T_5	$C_0B_2Z_0$	
T_{10}	$C_1B_1Z_1$		T_8	$C_1B_0Z_1$		T_2	$C_0B_0Z_1$	
T_{12}	$C_1B_2Z_1$		T_{13}	$C_2B_0Z_0$		T_{11}	$C_1B_2Z_0$	
T_2	$C_0B_0Z_1$		T_5	$C_0B_2Z_0$		T_{12}	$C_1B_2Z_1$	
T_8	$C_1B_0Z_1$		T_{11}	$C_1B_2Z_0$		T_1	$C_0B_0Z_0$	
T_{13}	$C_2B_0Z_0$		T_4	$C_2B_1Z_0$		T_6	$C_0B_2Z_1$	
T_5	$C_0B_2Z_0$		T_{14}	$C_2B_0Z_1$		T_{18}	$C_2B_2Z_1$	
T_6	$C_0B_2Z_1$		T_1	$C_0B_0Z_0$		T_{03}	$C_0B_1Z_0$	
T_{18}	$C_2B_2Z_1$		T_3	$C_0B_1Z_0$		T_{16}	$C_2B_1Z_1$	
T_1	$C_0B_0Z_0$		T_{16}	$C_2B_1Z_1$		T_{17}	$C_2B_2Z_0$	
T_9	$C_1B_1Z_0$		T_6	$C_0B_2Z_1$		T_8	$C_1B_0Z_1$	
T_7	$C_1B_0Z_0$		T_{18}	$C_2B_2Z_1$		T_{10}	$C_1B_1Z_1$	
T_{16}	$C_2B_1Z_1$		T_7	$C_1B_0Z_0$		T_{13}	$C_2B_0Z_0$	
T_{11}	$C_1B_2Z_0$		T_2	$C_0B_0Z_1$		T_{15}	$C_2B_1Z_0$	
T_{15}	$C_2B_1Z_0$		T_9	$C_1B_1Z_0$		T_7	$C_1B_0Z_0$	
T_{14}	$C_2B_0Z_1$		T_{17}	$C_2B_2Z_0$		T_9	$C_1B_1Z_0$	
T_3	$C_0B_1Z_0$		T_{12}	$C_1B_2Z_1$		T_{14}	$C_2B_0Z_1$	

---------------------------- Main irrigation channel ----------------------

Main –Path

Plate-1 : A field view of experimental plots

3.6 Preparation of the land

Land was ploughed twice with a tractor followed by clod breaking with disc plough, weed removal, field leveling and preparation of beds as per layout plan.

3.7 Application of fertilizers

Well rotten farm yard manure at 10 t ha^{-1} along with basal dose of nitrogen at 75 kg ha^{-1} phosphorus at 50 kg ha^{-1} and potassium at 50 kg ha^{-1} through urea, diammonium-phosphate (DAP) and muriate of potash (MOP) respectively, were applied fifteen days before planting of bulbs. Boron at 0.5 and 1.00 kg ha^{-1}, calcium at 5.00 and 10.00 kg ha^{-1} and zinc at 8.00 kg ha^{-1} were applied through borax, zinc sulphate and calcium nitrate, respectively.

3.8 Methods of soil analysis

Soil samples of the experimental field were taken before planting of bulbs and after harvest. Samples were air dried and ground in a wooden morter and pestle and passed through a 2 mm sieve. Prepared soil samples were analyzed for nitrogen (Jackson, 1973), phosphorus (Olsen *et al.*, 1954), potassium (Jackson, 1973), calcium (Piper, 1950), boron (Berger and Truog, 1939) and zinc (Piper, 1950) as per the standard procedure.

3.9 Planting of bulbs

Bulbs were planted on 26th October, 2008 and 29th October, 2009 at the experimental plots of Research Farm of Division of Floriculture, Medicinal and Aromatic Plants, SKUAST (K) Shalimar Campus.

3.10 Cultural practices

Uniform cultural practices were followed through the growth period. Irrigation, weeding-cum-hoeing and plant protection measures were carried out as and when required. Bulbs from representative plants were harvested and bagged separately for recording observations.

3.11 Biometrical observations

Observations were recorded from five representative plants per replication during both years. The mean values for different characters were subjected to statistical analysis. Following characters were studied :

3.12 Growth and physiological characters

3.12.1 Days taken to bulb sprouting

Number of days taken to bulb sprouting were counted from the date of planting of bulbs in plots till they were visible above soil in the plots.

3.12.2 Bulb sprouting (%)

Number of bulbs that sprouted were divided by the total number of bulbs planted per treatment and then per centage was calculated.

3.12.3 Plant height (cm)

The plant height of the representative plants was measured from ground level up to the apical floral bud with a meter rod at the time of anthesis.

3.12.4 Number of leaves plant^{-1}

The number of leaves plant^{-1} was counted from all representative plants in each replication.

3.12.5 Malformed leaves (%)

The number of leaves that failed to expand normally were counted and per centage of malformed leaves calculated.

3.12.6 Wrapper leaf area (cm^2)

Wrapper (lower most) leaves were taken from representative plants was measured with a leaf area meter (Systronics).

3.12.7 Leaf chlorophyll content (mg g^{-1})

Total chlorophyll content of the leaves was determined as per the method given by Hiscox and Israelstam (1979).

Leaf samples from each treatment, detached in morning hours were brought to laboratory and stored at 0^0C to avoid degradation of chlorophyll pigment. Leaves were washed and chopped to fine pieces under subdued light and 250 mg of chopped leaf samples were placed in vials containing 10 ml of Dimethyle Sulphoxide (DMSO). The contents of the vials were incubated at 65^0C temperature for half an hour and then extract was transferred to test tubes and the final volume was made to 20 ml with DMSO. The optical density (OD) values of the above extracts were recorded at 645 and 663 nm wavelengths against a DMSO blank by spectrophotometer. The total chlorophyll content was calculated by using following formula:

$$\text{Total chlorophyll (mg g}^{-1}\text{)} = \frac{20.2\ A_{645} + 8.02\ A_{663}}{a \times 1000 \times w} \times V$$

Where,

V = volume of the extract made

a = length of the light path in cell (usually 1 cm)

w = weight of the sample (g)

A_{645} = absorbance at 645 nm wavelength

A_{663} = absorbance at 663 nm wavelength

3.12.8 Leaf Ca (%), B (ppm) and Zn (mg g^{-1}) content

The plant samples collected were washed by tap water followed by dilute Hcl, single distilled water and double distilled water oven dried at 65□C for 4 hours and then grounded. The crushed material was passed through mesh size sieve and preserved in polythene bags for subsequent chemical analysis. Leaves of five randomly selected plants were taken separately and Ca, B and Zn content was checked on atomic absorption spectrophotometer.

Calcium content of plants samples was determined by digesting the sample with HNO_3 and Hcl reading was taken with atomic absorption spectrophotometer (Piper, 1950).

Boron content of plants samples was determined by dissolution of ashed material and its analysis for boron with a spectrophotometer (Berger and Truog, 1939).

The plant samples were digested in triacid mixture and analysed for total zinc by atomic absorption spectrophotometer (Piper, 1950).

3.12.9 Membrane stability index (%)

Membrane stability index (MSI) of petals was determined according to the method described by Health and Parker (1968). The Membrane stability index was calculated once in each year. The MSI was calculated from the per cent ion leakage in petal cells. Flower petals were rinsed well in tap water and then in deionised water prior to keeping them for incubation. One gram of petal tissues was submerged in test tubes containing 25 ml distilled water. After incubation for 3 hours at room temperature the conductivity (C_1) of the solution was measured by conductivity meter. After the petals were boiled for 10 minutes to kill all the tissues. After cooling at room temperature the conductivity (C_2) of the solution was again measured with conductivity meter. Then the Membrane stability index was calculated with the following formula:

$$\text{MSI (\%)} = 1 - \frac{C_1}{C_2} \times 100$$

3.12.10 Leaf N, P and K content (%)

Leaves of five randomly selected plants were taken separately and N, P and K content was estimated.

Nitrogen content of plant samples was estimated by Modified Kjeldahl's method (Jackson, 1973).

Phosphorus content was determined by Oslen's method (Oslen *et al*., 1954).

Potassium content was determined by flame photometer after extraction with neutral normal ammonium acetate (Jackson, 1973).

3.13 Floral characters

3.13.1 Days taken to appearance of floral bud

The number of days taken from bulb planting to first visible floral bud was recorded and the average number of days taken from planting to visible bud was worked out.

3.13.2 Bud blasting or malformed buds (%)

Number of floral buds that failed to open were counted and per centage of blasted flowers calculated.

3.13.3 Days to colour break

Date of full colouration of the outside of the perianth segment was recorded and days to colour break calculated from the data of visible floral bud.

3.13.4 Days to flower opening (anthesis)

Date of color break and full opening were recorded from the representative plants and days from colour break to full opening was calculated.

3.13.5 Flower diameter (cm)

The size of the flower was measured across the flower in centimeters when it was fully open with the help of a digital Vernier Callipers and average worked out.

3.13.6 Scape length (cm)

The length from each representative scape was measured in centimeters with the help of scale and average worked out.

3.13.7 Stem thickness (mm)

The stem thickness was measured at the middle of the stem (stalk) at the time of the anthesis of the flower.

3.13.8 Stem topple (%)

Number of floral buds in which stem collapses a few centimeters below the base of the flower was counted and percentage of blasted flowers calculated.

3.13.9 Field life (day)

The time in the field from planting until flowering was over was recorded.

3.14 Bulb characters

3.14.1 Number of bulbs lifted m^{-2}

The number of bulbs obtained per meter square were counted at harvest.

3.14.2 Weight of bulbs lifted m^{-2} (g)

Weight of bulbs was recorded from each representative plant by a digital electronic balance.

3.14.3 Weight of bulblets lifted m^{-2} (g)

The bulblets harvested from the representative plants were weighed in grams and the average weight per square meter was worked out by a digital electronic balance.

3.14.4 Bulb production ratio

Bulb production ratio was calculated by dividing the number of bulbs harvested by number of bulbs planted per treatment.

3.15 Vase life studies

Laboratory temperature and relative humidity was recorded during the period of investigation in cut tulips as under.

	2008-09	**2009-10**
Room temperature (^{o}C)	15.5-18.8	16.7-19.6
Relative Humidity (%)	30-35	42-46

The vase life observations were recorded according to the procedure given by Venkatarayappa *et al*. (1980). Data was recorded after placing the scapes in the distilled water. Vase life of the cut scapes was considered to be terminated when tepals showing sign of wilting. The observations recorded were:

3.15.1 Days taken to flower opening

Date of flower opening was recorded and then days calculated from the date of placing in the distilled water in vase.

3.15.2 Fresh weight changes (% of initial weight)

The difference between the weight of flask + solution + scape and weight of flask + solution represented the fresh weight (g) of the scape on the particular date.

$$FW = (C + S + F) - (C + S)$$

Where,

FW = Fresh weight

C = Container (flask)

S = Solution

F = Flower scape

After this, the per cent fresh weight change was calculated by the formula :

$$\text{Fresh weight change (\%)} = \frac{\text{Fresh weight of a particular day – initial fresh weight}}{\text{Initial fresh weight}} \times 100$$

3.15.2 Water uptake (g/scape)

The difference between consecutive measurements of the flask + solution (without scape) represented the water uptake.

$$W_U = (C + S)_1 – (C + S)_2$$

Where, W_U = Waster uptake

3.15.3 Water loss (g/scape)

The difference between consecutive measurements of flask + solution + flower scape represented the water loss.

$$W_L \text{ (Transpirational loss)} = (C + S + F)_1 – (C + S + F)_2$$

Where, W_L = Water loss

3.15.4 Water balance (g/scape)

Water uptake minus transpirational loss of water represented water balance.

$$W_B = W_U – W_L$$

Where, W_B = Water balance

3.15.5 Water loss/water uptake ratio

Transpirational loss of water divided by uptake represented the water loss/water uptake ratio.

$$\text{Ratio} = \frac{W_L}{W_U}$$

3.15.6 Flower diameter (cm)

The size of the flower from each representative scape was measured in centimeters when it was fully open with the help of a measuring scale and average worked out.

3.15.7 Vase life (day)

Number of days was counted from the date of opening till tepals till senescence was taken as the vase life.

3.16 Physico-chemical characters of experimental soil

3.16.1 Soil pH {before and after experiment}

The pH of the soil was determined in 1:2.5 soil water suspension with the help of glass electrode pH meter.

3.16.2 Electric conductivity (ds/m) {before and after experiment}

The electric conductivity of the soil was estimated in 1:2.5 soil water suspension with the help of solubridge conductivity meter.

3.16.3 Soil N, P, K, B, Ca and Zn contents (%) {before and after experiment}

Prepared soil samples were analyzed for nitrogen, phosphorus, potassium, calcium , boron and zinc as per the standard procedure as mentioned under heading 3.8.

Soil characteristics	Year			
	2008-09		2009-10	
	Before	After	Before	After
pH	7.95	7.93	7.94	7.92
Electric conductivity (ds m^{-1})	0.52	0.54	0.54	0.55
Nitrogen content (kg ha^{-1})	210	212	211	212.05
Phosphorus content (kg ha^{-1})	49	49.81	50	51.00
Potassium content (kg ha^{-1})	84	84.72	84.2	84.91
Boron (%)	2.5	2.6	2.54	2.61
Calcium (%)	10.5	11.0	10.57	11.21
Zinc (%)	1.1	1.21	1.3	1.41

3.17 Relative economics

The cost benefit ratio of the experiment was worked out by calculating the cost of each treatment used. The cost : benefit ratio was calculated with the following formula.

Cost benefit ratio = Net income (Rs)/Total cost of cultivation (Rs)

3.18 Statistical analysis

Experimental data were subjected to statistical analysis in randomized block design as per the procedure described by Panse and Sukhatme (1985). The levels of significance used “F” and “T” tests were $p = 0.05$ as given by Fisher (1970). The standard error of mean between any two treatment means and critical difference have been worked out accordingly.

CHAPTER – 4

EXPERIMENTAL FINDINGS

The results obtained during the present investigation entitled “Effect of calcium, boron and zinc on growth, flowering and bulb production of tulip (*Tulipa gesneriana* L.) cv. Apeldoorn” are presented in this chapter. The silent features of various parameters studied are given as under :

4.1 Growth and physiological character

4.1.1 Days taken to bulb sprouting

The data with regard to the individual effect of Ca, B and Zn on days taken to bulb sprouting are presented in Table 4.1.1.

A close perusal of the data indicates that application of Ca, B and Zn slightly reduced the days taken to bulb sprouting. However, statistical analysis of the data revealed that the differences in time taken to bulb sprouting among the different treatments were non significant.

The interaction effects of Ca × B, Ca × Zn and B × Zn are presented in Table 4.1.2. Data revealed that the days taken to bulb sprouting was decreased with increasing levels of nutrients but the decrease was found to be negligible when analysed statistically. It is further to be noted that all possible interaction of two factors could produce only non significant difference so far as days taken to bulb sprouting is concerned.

The combined effect of Ca, B and Zn on days taken to bulb sprouting is presented in Table 4.1.3. Inspection of the data with regard to combined effect of Ca, B and Zn reflect that differences in days taken to bulb sprouting was again non significant and hence these treatments were not effective for getting the early sprouting in tulip.

4.1.1.2 Bulb sprouting (%)

It was interesting to note that during both the years of study, calcium had a significant influence on bulb sprouting per cent. So far as the individual effects are concerned, the application of each individual nutrient markedly increased the bulb sprouting per cent. However, the maximum sprouting per cent was obtained with calcium 10.00 kg ha^{-1}(99.89%) followed by boron 1.00 kg ha^{-1} (99.09 %) and Zn 8.00 kg ha^{-1} (98.60%) (Table 4.1.1 and Fig. 1).

Perusal of the data with regard to interaction effect of Ca × B, Ca × Zn and B × Zn on bulb sprouting per cent revealed that interaction between different levels of calcium and boron caused a significant improvement in bulb sprouting (%). The maximum bulb sprouting (100.00%) was observed under application of 10.00 kg of Ca ha^{-1} and 8.00 kg of B ha^{-1}(C_2B_2) and minimum (95.59%) was recorded under C_0B_0 (control) (Table 4.1.2).

The magnitude of superiority of C_2Z_1 (100%) over C_0Z_0 and other Ca and Zn interactions with regard to bulb sprouting per cent is also clear from the data presented in Table 4.1.2.

Various treatment combinations of boron and zinc further resulted significant variations in bulb sprouting per cent. It is vivid from the data (Table 4.1.2) that maximum (99.11%) and minimum (97.68%) bulb sprouting was recorded under B_2Z_1 and B_0Z_0 treatment combinations, respectively.

The data about the interaction effects between calcium, boron and zinc revealed that the bulb sprouting per cent increased significantly from 95.58 to 100.00 per cent with enhancement of calcium, boron and zinc dose from 0.00 to 10.00, 0.00 to 1.00 and 0.00 to 8.00 kg ha^{-1}, respectively (Table 4.1.3).

4.1.1.3 Plant height (cm)

The data on the plant height as influenced by different nutrients during investigation are presented in Table-4.1.1 and Fig. 1.

Perusal of data indicates that plant height is a function of different nutrients and is influenced significantly by various treatments. The maximum plant height (37.10 cm) was recorded with Ca (10.00 kg ha^{-1}) followed by B 1.00 kg ha^{-1}(36.03 cm) and Zn 8.00 kg ha^{-1}(35.47 cm), whereas the minimum plant height was recorded under untreated controls.

The interactive influences of two factors together are presented in Table-4.1.2. Effect of Ca × B showed that the maximum plant height (38.03 cm) was recorded in calcium (10.00 kg ha^{-1}) with boron (1.00 kg ha^{-1}) followed by 36.93 cm in C_2B_1 and 36.34 cm in C_2B_0, whereas the minimum plant height (33.49 cm) was recorded under control.

The second highest plant height (37.26 cm) was recorded under the interaction between calcium (10.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}).

The interaction of the highest doses of B (1.00 kg ha^{-1}) and Zn (8.00 kg ha^{-1}) resulted a plant height of 36.20 cm which was virtually inferior to few other treatments of Ca × B as well as Ca × Zn.

Perusal of data (Table-4.1.3) on plant height revealed that interaction between calcium, boron and zinc also had a significant effect on plant height during both the years of investigations. The maximum plant height (38.18 cm) was recorded with the interaction of C_2 (10.00 kg ha^{-1}), B_2 (1.00 kg ha^{-1}) Z_1 (8.00 kg ha^{-1}), which was followed in descending order by 37.87 cm in $C_2B_2Z_0$, 37.10 cm in $C_2B_1Z_1$ and 36.77 cm in $C_2B_1Z_0$ whereas, the minimum plant height was recorded with lowest level of C_0, B_0 and Z_0 and that was 33.43 cm.

4.1.1.4 Number of leaves plant^{-1}

The perusal of mean values for number of leaves plant^{-1} (Table 4.1.1 and Fig. 1) under the influence of three nutrients indicated that highest number of leaves plant^{-1} (4.84) was noted with Ca (10.00 kg ha^{-1}) followed by 4.66 leaves in Ca (5.00 kg ha^{-1}) and the lowest (4.36 leaves plant^{-1}) in Ca (0.00 kg ha^{-1}). It is

Table 4.1.1: Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Number of days taken to bulb sprouting			Bulb sprouting (%)			Plant height (cm)			Number of leaves per plant		
	2008-09	2009-10	Pooled	2008-09	2009	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Calcium (kg ha^{-1})												
C_0 (0)	69.62	68.41	69.02	97.22	97.23	97.23	33.33	34.48	33.9	4.48	4.24	4.36
C_1 (5.00)	68.84	67.65	68.24	97.77	98.80	98.29	34.49	35.65	35.07	4.74	4.58	4.66
C_2 (10.00)	67.78	66.56	67.17	99.86	99.93	99.89	36.52	37.68	37.10	4.83	4.86	4.84
C.D$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.98**	**0.29**	**0.62**	**0.18**	**0.18**	**0.01**	**0.08**	**0.05**	**0.06**
Boron (kg ha^{-1})												
B_0 (0)	69.006	67.81	68.40	97.50	98.22	97.86	34.22	35.39	34.81	4.61	4.46	4.53
B_1 (0.5)	68.82	67.59	68.20	98.33	98.58	98.46	34.66	35.82	35.24	4.67	4.56	4.61
B_2 (1.00)	68.42	67.22	67.82	99.02	99.16	99.09	35.46	36.6	36.03	4.77	4.66	4.71
C.D$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.98**	**0.29**	**0.62**	**0.18**	**0.18**	**0.01**	**0.08**	**0.05**	**0.06**
Zinc (kg ha^{-1})												
Z_0 (0)	68.82	67.63	68.23	98.14	98.54	98.34	34.66	35.82	35.24	4.64	4.53	4.58
Z_1 (8.00)	68.67	67.45	68.06	98.42	98.77	98.60	34.89	36.05	35.47	4.74	4.59	4.66
C.D$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.80**	**0.24**	**0.50**	**0.15**	**0.15**	**0.15**	**0.06**	**0.04**	**0.05**

NS = Non-significant

Table 4.1.2 : Interaction effect of Ca x B, Ca x Zn and B x Zn on vegetative and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Number of days taken to bulb sprouting			Bulb sprouting (%)			Plant height (cm)			Number of leaves per plant		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Ca x B (kg ha^{-1})												
C_0B_0	69.83	68.63	69.23	95.00	96.18	95.59	32.91	34.08	33.49	4.35	4.15	4.25
C_0 B_1	69.70	68.46	69.08	97.50	97.03	97.27	33.28	34.45	33.87	4.45	4.25	4.35
C_0 B_2	69.35	68.15	68.75	97.50	98.73	98.12	33.79	34.9	34.35	4.66	4.33	4.50
C_1B_0	69.15	67.96	68.55	97.92	98.68	98.30	34.00	35.17	34.58	4.70	4.45	4.57
C_1 B_1	68.95	67.71	68.33	97.92	99.00	98.46	34.34	35.51	34.93	4.76	4.58	4.67
C_1 B_2	68.43	67.26	67.85	99.17	98.50	98.83	35.13	36.28	35.71	4.76	4.71	4.74
C_2 B_0	68.03	66.83	67.43	99.58	99.80	99.69	35.76	36.93	36.34	4.80	4.80	4.80
C_2 B_1	67.81	66.60	67.20	100.00	100.00	100.00	36.35	37.52	36.93	4.81	4.86	4.84
C_2 B_2	67.50	66.26	66.88	100.00	100.00	100.00	37.45	38.6	38.03	4.90	4.93	4.91
CD$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**1.71**	**0.51**	**1.07**	**0.73**	**0.73**	**0.53**	**0.14**	**0.09**	**0.11**
Ca x Zn (kg ha^{-1})												
C_0Z_0	69.67	68.46	69.07	97.22	97.46	97.34	33.27	34.41	33.84	4.37	4.21	4.29
C_0Z_1	69.57	68.36	68.97	97.22	97.02	97.12	33.38	34.54	33.96	4.60	4.27	4.43
C_1Z_0	68.92	67.74	68.33	97.50	98.73	98.12	34.37	35.54	34.95	4.74	4.55	4.65
C_1Z_1	68.76	67.55	68.16	98.06	98.88	98.47	34.61	35.77	35.19	4.74	4.61	4.67
C_2Z_0	67.87	66.68	67.28	99.72	99.87	99.79	36.35	37.52	36.94	4.80	4.83	4.81
C_2Z_1	67.68	66.44	67.06	100.00	100.00	100.00	36.69	37.84	37.26	4.87	4.90	4.88
CD$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.78**	**0.42**	**0.87**	**0.59**	**0.14**	**0.43**	**0.11**	**0.07**	**0.09**
B x Zn (kg ha^{-1})												
B_0 Z_0	69.02	67.84	68.43	97.22	98.14	97.68	34.14	35.3	34.72	4.55	4.44	4.50
B_0 Z_1	68.98	67.77	68.38	97.77	98.30	98.03	34.31	35.48	34.89	4.63	4.54	4.58
B_1 Z_0	68.91	67.71	68.31	98.05	98.41	98.23	34.58	35.74	35.16	4.67	4.48	4.58
B_1 Z_1	68.73	67.47	68.10	98.61	98.76	98.68	34.74	35.91	35.32	4.72	4.58	4.65
B_2 Z_0	68.54	67.34	67.94	98.88	99.26	99.07	35.28	36.43	35.85	4.73	4.61	4.67
B_2 Z_1	68.31	67.11	67.71	99.16	99.06	99.11	35.63	36.77	36.20	4.82	4.71	4.76
CD$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.78**	**0.07**	**0.87**	**0.14**	**0.59**	**0.43**	**0.11**	**0.07**	**0.09**

NS = Non - significant

Table 4.1.3: Combined effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Number of days taken to bulb sprouting			Bulb sprouting (%)			Plant height (cm)			Number of leaves per plant		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
C_0 B_0 Z_0	69.83	68.63	69.23	95.00	96.17	95.58	32.84	34.01	33.43	4.10	4.13	4.11
C_0 B_0 Z_1	69.83	68.63	69.23	95.00	96.20	95.60	32.98	34.14	33.56	4.20	4.56	4.38
C_0 B_1 Z_0	69.73	68.50	69.11	96.67	96.50	96.58	33.27	34.44	33.85	4.23	4.33	4.28
C_0 B_1 Z_1	69.66	68.43	69.05	98.33	97.57	97.95	33.3	34.46	33.88	4.26	4.56	4.41
C_0 B_2 Z_0	69.46	68.26	68.86	100.00	98.40	99.20	33.69	34.79	34.24	4.30	4.66	4.48
C_0 B_2 Z_1	69.23	68.03	68.63	98.33	98.73	98.47	33.88	35.02	34.45	4.36	4.66	4.51
C_1 B_0 Z_0	69.16	68.00	68.58	97.50	98.60	98.08	33.98	35.14	34.56	4.43	4.70	4.56
C_1 B_0 Z_1	69.13	67.93	68.53	98.33	98.67	98.52	34.02	35.19	34.61	4.46	4.70	4.58
C_1 B_1 Z_0	69.10	67.90	68.50	97.50	98.70	98.12	34.28	35.44	34.86	4.53	4.76	4.65
C_1 B_1 Z_1	68.80	67.53	68.16	97.50	98.60	98.12	34.41	35.58	34.99	4.63	4.76	4.70
C_1B_2 Z_0	68.50	67.33	67.91	97.50	98.73	98.15	34.86	36.03	35.45	4.70	4.76	4.73
C_1 B_2 Z_1	68.36	67.20	67.78	98.33	98.73	98.77	35.40	36.54	35.97	4.73	4.76	4.75
C_2 B_0 Z_0	68.06	66.90	67.48	99.17	98.80	99.38	35.59	36.76	36.17	4.80	4.76	4.78
C_2B_0 Z_1	68.00	66.76	67.38	100.00	99.20	100.00	35.93	37.1	36.51	4.80	4.83	4.81
C_2 B_1 Z_0	67.90	66.73	67.31	100.00	99.60	100.00	36.18	37.35	36.77	4.83	4.76	4.80
C_2 B_1 Z_1	67.73	66.46	67.10	100.00	98.40	99.20	36.52	37.68	37.10	4.86	4.80	4.83
C_2 B_2 Z_0	67.66	66.43	67.05	100.00	100.00	100.00	37.29	38.46	37.87	4.86	4.83	4.85
C_2 B_2 Z_1	67.33	66.10	66.71	100.00	100.00	100.00	37.62	38.75	38.18	5.03	5.03	5.03
$C.D_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**2.42**	**0.73**	**1.52**	**1.03**	**1.03**	**0.76**	**0.20**	**0.13**	**0.15**

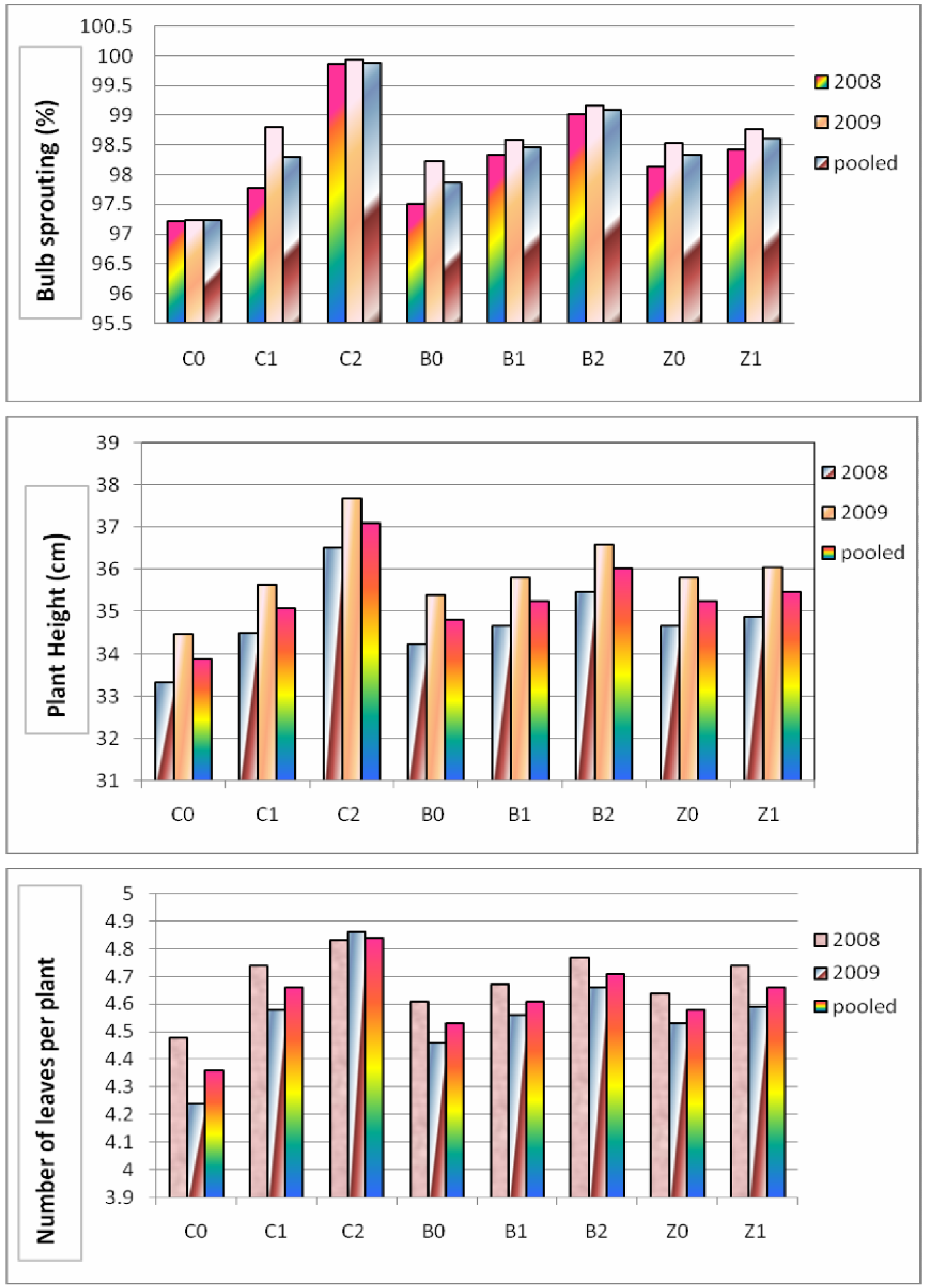


Fig. 1 : **Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)**

further to be noted that the increased levels of the individual nutrients caused a significant increase in the number of leaves per plant.

The interaction effects of Ca × B, Ca × Zn and B × Zn on number of leaves per plant are presented in Table 4.1.2. The influence of interaction between calcium and boron levels in terms of number of leaves per plant was significant. Maximum number of leaves per plant (4.91) was observed in Ca (10.00 kg ha^{-1}) and boron (1.00 kg ha^{-1}). Whereas 4.25 leaves per plant was recorded with no application of calcium and boron.

The interaction between calcium and zinc also influenced the number of leaves per plant significantly (Table 4.1.2). Highest number of leaves per plant (4.88) was recorded under the influence of calcium at 10.00 kg ha^{-1} and 8.00 kg ha^{-1} zinc, whereas, the lowest number of leaves per plant (4.29) was recorded under calcium at 0.00 kg ha^{-1} alongwith Zn at 0.00 kg ha^{-1}.

Data further revealed significantly maximum number of leaves $plant^{-1}$ (4.76) under the influence of boron at 1.00 kg ha^{-1} and zinc 8.00 kg ha^{-1}, whereas, the minimum number of leaves per plant (4.50) was recorded under boron and zinc at 0.00 kg ha^{-1}.

Interactions between calcium, boron and zinc (Table 4.1.3) revealed that maximum number of leaves $plant^{-1}$ (5.03) was recorded under the influence of calcium at 10.00 kg ha^{-1}, boron at 1.00 kg ha^{-1} and 8.00 kg ha^{-1} of Zn, while minimum number of leaves (4.11) was recorded under $C_0B_0Z_0$. The interaction between $C_2B_2Z_0$, $C_2B_1Z_1$, $C_2B_1Z_o$ and $C_2B_oZ_1$ were statistically at par.

4.1.1.5 Malformed leaves (%)

Individual effects of different nutrients and their levels depicted a significant differences in malformed leaves (Table 4.1.4). There was a significant decrease in per cent malformed leaves when nutrients were applied. Application of Ca at 10.00 kg ha^{-1} resulted in lowest per cent of malformed leaves (0.11%) followed in ascending order by application of boron at 1.00 kg ha^{-1} (0.50%) and zinc at 8.00 kg ha^{-1} (0.59%) against maximum per cent of malformed leaves (1.08) in control. It was further to be noted that increased levels of each nutrient caused a decreased per cent of malformed leaves and hence there was an inverse relationship between dose of nutrients and per cent malformed leaves.

The interaction effects of Ca × B, Ca × Zn and B × Zn on per cent of malformed leaves is presented in Table 4.1.5.

Under the interactive influence of calcium and boron, minimum (0.00 %) and maximum (1.25%) malformed leaves were observed for calcium (10.00 kg ha^{-1}) plus boron (1.00 kg ha^{-1}) and control, respectively.

The interaction between C_2B_1, C_2B_0 and C_1B_2 were statistically at par with each other at 5 per cent level of significance.

Data on the interaction effect between calcium and zinc revealed that the minimum malformed leaves (0.05%) was recorded with C_2Z_1 against the highest malformed leaves of 1.11% in untreated control (C_0Z_0).

Interaction of B and Zn further revealed a significant difference in malformed leaves in nutrient applied plots and the minimum malformed leaves per cent was recorded with highest doses of B (1.00 kg ha^{-1}) and Zn 8.00 kg ha^{-1}.

Various treatment combinations of calcium, boron and zinc resulted a significant variations in malformed leaves. It is vivid from the data (Table-4.1.6) that significantly lowest (0.00%) and highest (1.33%) malformed leaves were recorded under $C_2B_2Z_1$ and $C_0B_0Z_0$ treatment combinations, respectively. However, the interactions between treatment combinations of $C_2B_2Z_0$, $C_2B_1Z_1$ and $C_2B_1Z_0$ were at par at 5 per cent level of significance.

4.1.1.6 Wrapper leaf area (cm^2)

The three treatments tried in this study, revealed significant variations in the wrapper leaf area (Table-4.1.4 and Fig. 2). Maximum leaf area (232.35 cm^2) was recorded in calcium 10.00 kg ha^{-1} and minimum leaf area (145.42 cm^2) in calcium 0.00 kg ha^{-1}. Application of B at 1.00 kg ha^{-1} resulted in second highest leaf area (205.27 cm^2) followed by a leaf area of 189.09 cm^2 under the application of Zn at 8.00 kg ha^{-1}.

Data with regard to two way interactions are presented in Table-4.1.5. A favourable interaction of different levels of calcium with boron was also observed in the present study. Largest leaf area (278.09 cm^2) was recorded with highest level of calcium (10.00 kg ha^{-1}) and boron (1.00 kg ha^{-1}) and the lowest leaf area 134.91 cm^2 with lowest level of calcium and boron (0.00 kg ha^{-1}).

The interaction between calcium and zinc levels influenced the wrapper leaf area significantly, maximum wrapper leaf area (241.37 cm^2) was found with calcium (10.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) and lowest wrapper leaf area (141.39 cm^2) was observed with 0.00 kg ha^{-1} each of calcium and zinc. However, the interactions between treatment combination C_1Z_1 and C_1Z_0 was statistically at par at 5 per cent level of significance.

The interaction data (Table 4.1.5) further revealed significantly higher wrapper leaf area (210.63 cm^2) under the influence of boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}).

It is evident from the Table-4.1.6 that combined effect of calcium, boron and zinc had a significant influence on wrapper leaf area. Treatment combination of $C_2B_2Z_1$ recorded maximum wrapper leaf area of 179.86 cm^2, which was followed by $C_2B_2Z_0$ (179.08 cm^2) and $C_2B_1Z_1$ (176.85 cm^2). Minimum leaf area was, however, recorded by $C_0B_0Z_0$ (164.79 cm^2).

4.1.1.7 Leaf chlorophyll content (mg g^{-1})

Different treatments tested in the present investigations depicted significant differences in the leaf chlorophyll content (Table 4.1.4 and Fig. 2). Maximum chlorophyll content (0.51 mg g^{-1}) was recorded in calcium 10.00 kg ha^{-1}), whereas lowest chlorophyll content (0.37 mg g^{-1}) was recorded in calcium (0.00 kg ha^{-1}).

Perusal of mean values (Table 4.1.4) for leaf chlorophyll content under different boron levels reflected that application of boron caused significant increase in leaf chlorophyll content, however, increase in application rate of boron from 0.50 to 1.00 kg ha^{-1} depicted significant increase in leaf chlorophyll content. The highest leaf chlorophyll content (0. 46 mg g^{-1}) was observed under boron at 1.00 kg ha^{-1} (B_2) and the lowest leaf chlorophyll content (0.41 mg g^{-1}) was observed under boron at 0.00 kg ha^{-1} (B_0). Increase in zinc application rate from 0.00 to 8.00 kg ha^{-1} registered a positive impact on leaf chlorophyll content while the maximum leaf chlorophyll content (0. 45 mg g^{-1}) was recorded under 8.00 kg Zn ha^{-1}. Minimum leaf chlorophyll content (0.43 mg g^{-1}) was recorded under 0.00 kg Zn ha^{-1} (Table 4.1.4).

Data presented in Table-4.1.5 revealed that the interaction between calcium and boron levels proved to be beneficial in improving the leaf chlorophyll content. The treatment combination C_2B_2 recorded the highest leaf chlorophyll content (0.55 mg g^{-1}) whereas the lowest leaf chlorophyll content of (0. 35 mg g^{-1}) was recorded under C_0B_0 treatment combination.

Leaf chlorophyll content altered significantly due to different levels of calcium and zinc as well. Tulip plants receiving 10.00 kg calcium ha^{-1} and 8.00 kg zinc ha^{-1} showed maximum chlorophyll content (0.52 mg g^{-1}) followed by C_2Z_0 application which produced (0.50 mg g^{-1}) leaf chlorophyll content whereas minimum chlorophyll content (0. 36 mg g^{-1}) was recorded under 0.00 kg ha^{-1} each of calcium and zinc.

Among the interactive influences of B and Zn, the maximum chlorophyll content (0.47 mg g^{-1}) was recorded under B_2Z_1 whileas, the minimum leaf chlorophyll content (0.40 mg g^{-1}) was observed under B_0Z_0 treatment combination.

The interaction between different levels of calcium, boron and zinc also produced a significant variation in this character (Table 4.1.6). Maximum chlorophyll content (0.56 mg g^{-1}) was observed under $C_2B_2Z_1$ treatment combination followed by $C_2B_2Z_0$ (0.53 mg g^{-1}) and $C_2B_1Z_1$ (0.52 mg g^{-1}) while minimum leaf chlorophyll content (0.34 mg g^{-1}) was recorded under $C_0B_0Z_0$. However, the interaction between $C_2B_0Z_0$ and $C_1B_2Z_1$ were statistically at par.

4.1.1.8 Leaf boron content (ppm)

Analysis of variance indicated that individual effects of calcium, boron and zinc levels and their interactions thereof resulted in significant variation in leaf boron content.

Data pertaining to individual effects (Table 4.1.4 and Fig. 2) indicate that leaf boron content produced by different calcium levels differed statistically at 5 per cent level of significance. Maximum boron content (27.52 ppm) was recorded in calcium (10.00 kg ha^{-1}) followed by 25.13 ppm in 5.00 kg calcium ha^{-1} while minimum boron content (25.13 ppm) was recorded under zero nutrient application.

Perusal of mean values for leaf boron content under different boron levels revealed that application of boron had a significant positive impact on the leaf boron content. The highest boron content (25.77 ppm) was observed under 1.00 kg ha^{-1} followed by 0.5 kg ha^{-1} and lowest (24.11 ppm) boron content was observed under 0.00 kg ha^{-1}.

Application of zinc at 00.0 to 8.00 kg ha^{-1} registered a marked increase in leaf boron content (25.21 ppm) against the minimum boron content of 24.66 ppm recorded under 0.00 kg zinc ha^{-1}.

The two way interaction effects data (Table 4.1.5) clearly indicated that with the increase in rate of application of calcium and boron there occurred a corresponding increase in leaf boron content. The leaf boron content was highest (28.19 ppm) under C_2B_2 followed by 27.53 ppm under C_2B_1 and minimum (21.19 ppm) was recorded under C_0B_0.

Though the leaf boron content was influenced by interaction between

Table 4.1.4: Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Malformed leaves (%)			Wrapper leaf area (cm^2)			Leaf chlorophyll content (mg g^{-1})			Leaf Boron content (ppm)		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Calcium (kg ha^{-1})												
C_0 (0)	1.05	1.11	1.08	145.81	145.03	145.42	0.35	0.39	0.37	25.0	25.1	25.13
C_1 (5.00)	0.94	0.55	0.75	174.26	177.85	176.06	0.42	0.46	0.44	25.0	25.1	25.13
C_2 (10.00)	0.22	0.00	0.11	231.70	233.01	232.35	0.49	0.53	0.51	27.4	27.5	27.52
C.D$_{(P\leq0.05)}$	**0.23**	**0.21**	**0.16**	**1.04**	**0.98**	**0.83**	**0.005**	**0.005**	**0.005**	**0.06**	**0.06**	**0.06**
Boron (kg ha^{-1})												
B_0 (0)	0.88	0.77	0.83	165.40	169.65	167.52	0.40	0.44	0.41	24.0	24.1	24.11
B_1 (0.5)	0.72	0.50	0.61	179.38	182.71	181.05	0.42	0.46	0.44	24.8	24.9	24.93
B_2 (1.00)	0.61	0.38	0.50	207.01	203.53	205.27	0.45	0.49	0.46	25.7	25.8	25.77
C.D$_{(P\leq0.05)}$	**0.23**	**0.21**	**0.16**	**1.04**	**0.98**	**0.83**	**0.005**	**0.005**	**0.005**	**0.06**	**0.06**	**0.06**
Zinc (kg ha^{-1})												
Z_0 (0)	0.81	0.59	0.70	180.21	180.06	180.14	0.41	0.45	0.43	24.6	24.7	24.66
Z_1 (8.00)	0.66	0.51	0.59	187.64	190.53	189.09	0.43	0.47	0.45	25.1	25.2	25.21
C.D$_{(P\leq0.05)}$	**0.19**	**0.17**	**0.13**	**0.85**	**0.80**	**0.67**	**0.004**	**0.004**	**0.004**	**0.05**	**0.05**	**0.05**

Table 4.1.5 : Interaction effect of Ca x B, Ca x Zn and B x Zn on vegetative and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Malformed leaves (%)			Wrapper leaf area (cm^2)			Leaf chlorophyll content ($mg\ g^{-1}$)			Leaf boron content (ppm)		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Ca x B (kg ha^{-1})												
C_0B_0	1.16	1.33	1.25	134.13	135.70	134.91	0.33	0.37	0.35	21.16	21.22	21.19
C_0 B_1	1.00	1.00	1.00	145.97	146.35	146. 16	0.35	0.39	0.36	22.06	22.13	22.10
C_0 B_2	1.00	1.00	1.00	157.34	153.04	155.19	0.37	0.41	0.39	23.16	23.22	23.19
C_1B_0	1.00	1.00	1.00	166.31	172.72	169.51	0.40	0.44	0.41	24.26	24.36	24.31
C_1 B_1	1.00	0.50	0.75	174.60	177.67	176.14	0.42	0.46	0.44	25.11	25.20	25.16
C_1 B_2	0.83	0.16	0.50	181.89	183.17	182.53	0.44	0.48	0.46	25.90	25.97	25.93
C_2 B_0	0.50	0.00	0.25	195.75	200.52	198.13	0.46	0.50	0.48	26.78	26.88	26.83
C_2 B_1	0.16	0.00	0.08	217.56	224.11	220.84	0.49	0.53	0.51	27.46	27.60	27.53
C_2 B_2	0.00	0.00	0.00	281.79	274.39	278.09	0.53	0.57	0.55	28.11	28.27	28.19
$CD_{(P\leq0.05)}$	**0.40**	**0.38**	**0.28**	**1.81**	**1.70**	**1.43**	**0.009**	**0.009**	**0.009**	**0.11**	**0.11**	**0.10**
Ca x Zn (kg ha^{-1})												
C_0Z_0	1.11	1.11	1.11	142.55	140.23	141.39	0.34	0.38	0.36	21.80	21.86	21.83
C_0Z_1	1.00	1.11	1.05	149.08	149.83	149.45	0.35	0.39	0.37	22.46	22.52	22.50
C_1Z_0	1.00	0.66	0.83	172.66	178.69	175.68	0.41	0.45	0.43	24.82	24.91	24.86
C_1Z_1	0.88	0.44	0.66	175.86	177.02	176.44	0.43	0.47	0.45	25.36	25.44	25.41
C_2Z_0	0.33	0.00	0.16	225.43	221.26	223.34	0.48	0.52	0.50	27.24	27.34	27.29
C_2Z_1	0.11	0.00	0.05	237.98	244.75	241.37	0.51	0.55	0.52	27.66	27.82	27.74
$CD_{(P\leq0.05)}$	**0.33**	**0.03**	**0.23**	**1.48**	**1.38**	**1.17**	0.007	0.007	0.007	**0.09**	**0.09**	**0.09**
B x Zn (kg ha^{-1})												
B_0 Z_0	1.00	0.77	0.88	161.42	166.36	163.89	0.39	0.43	0.40	23.83	23.89	23.86
B_0 Z_1	0.77	0.77	0.77	169.38	172.93	171.15	0.40	0.44	0.42	24.31	24.42	24.37
B_1 Z_0	0.77	0.55	0.66	175.44	177.78	176.61	0.41	0.45	0.43	24.62	24.72	24.67
B_1 Z_1	0.66	0.44	0.55	183.32	187.64	185.48	0.43	0.47	0.45	25.14	25.23	25.19
B_2 Z_0	0.66	0.44	0.55	203.78	196.04	199.91	0.44	0.48	0.45	25.41	25.50	25.45
B_2 Z_1	0.55	0.33	0.44	210.23	211.03	210.63	0.46	0.50	0.47	26.04	26.13	26.09
$CD_{(P\leq0.05)}$	**0.33**	**0.03**	**0.23**	**1.48**	**1.38**	**1.17**	**0.007**	**0.007**	**0.007**	**0.09**	**0.09**	**0.08**

Table 4.1.6: Combined effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Malformed leaves (%)			Wrapper leaf area (cm^2)			Leaf chlorophyll content ($mg\ g^{-1}$)			Leaf boron content (ppm)		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
$C_0\ B_0\ Z_0$	1.33	1.33	1.33	163.53	166.06	164.79	0.32	0.36	0.34	20.86	20.90	20.89
$C_0\ B_0\ Z_1$	1.00	1.33	1.16	164.47	166.87	165.67	0.34	0.38	0.35	21.46	21.54	21.50
$C_0\ B_1\ Z_0$	1.00	1.00	1.00	165.23	167.93	166.58	0.34	0.38	0.36	21.86	21.93	21.90
$C_0\ B_1\ Z_1$	1.00	1.00	1.00	166.35	169.38	167.86	0.35	0.39	0.37	22.26	22.33	22.30
$C_0\ B_2\ Z_0$	1.00	1.00	1.00	167.69	170.82	169.25	0.37	0.41	0.38	22.66	22.73	22.70
$C_0\ B_2\ Z_1$	1.00	1.00	1.00	169.17	171.97	170.57	0.38	0.42	0.39	23.66	23.70	23.69
$C_1\ B_0\ Z_0$	1.00	0.66	0.83	169.69	172.49	171.09	0.39	0.43	0.40	24.06	24.13	24.10
$C_1\ B_0\ Z_1$	1.00	0.66	0.83	170.01	172.81	171.41	0.41	0.45	0.42	24.46	24.60	24.53
$C_1\ B_1\ Z_0$	1.00	0.66	0.83	170.42	173.22	171.82	0.41	0.45	0.43	24.86	24.97	24.92
$C_1\ B_1\ Z_1$	1.00	0.33	0.66	171.70	174.37	173.03	0.43	0.47	0.45	25.36	25.44	25.40
$C_1B_2\ Z_0$	1.00	0.33	0.66	172.19	174.86	173.52	0.43	0.47	0.45	25.53	25.63	25.58
$C_1\ B_2\ Z_1$	0.66	0.33	0.50	172.94	175.67	174.30	0.45	0.49	0.47	26.26	26.30	26.29
$C_2\ B_0\ Z_0$	0.66	0.33	0.50	173.92	176.58	175.25	0.46	0.50	0.47	26.56	26.63	26.60
$C_2B_0\ Z_1$	0.33	0.00	0.16	174.09	176.76	175.43	0.47	0.51	0.49	27.00	27.14	27.07
$C_2\ B_1\ Z_0$	0.33	0.00	0.16	174.81	177.48	176.14	0.48	0.52	0.50	27.13	27.27	27.20
$C_2\ B_1\ Z_1$	0.00	0.00	0.00	175.52	178.18	176.85	0.50	0.54	0.52	27.80	27.93	27.87
$C_2\ B_2\ Z_0$	0.00	0.00	0.00	177.91	180.24	179.08	0.51	0.55	0.53	28.03	28.14	28.09
$C_2\ B_2\ Z_1$	0.00	0.00	0.00	178.56	181.16	179.86	0.55	0.59	0.56	28.20	28.40	28.30
$C.D_{(P\leq 0.05)}$	**0.57**	**0.78**	**0.57**	**1.84**	**1.66**	**1.71**	**0.01**	**0.01**	**0.01**	**0.16**	**0.16**	**0.15**

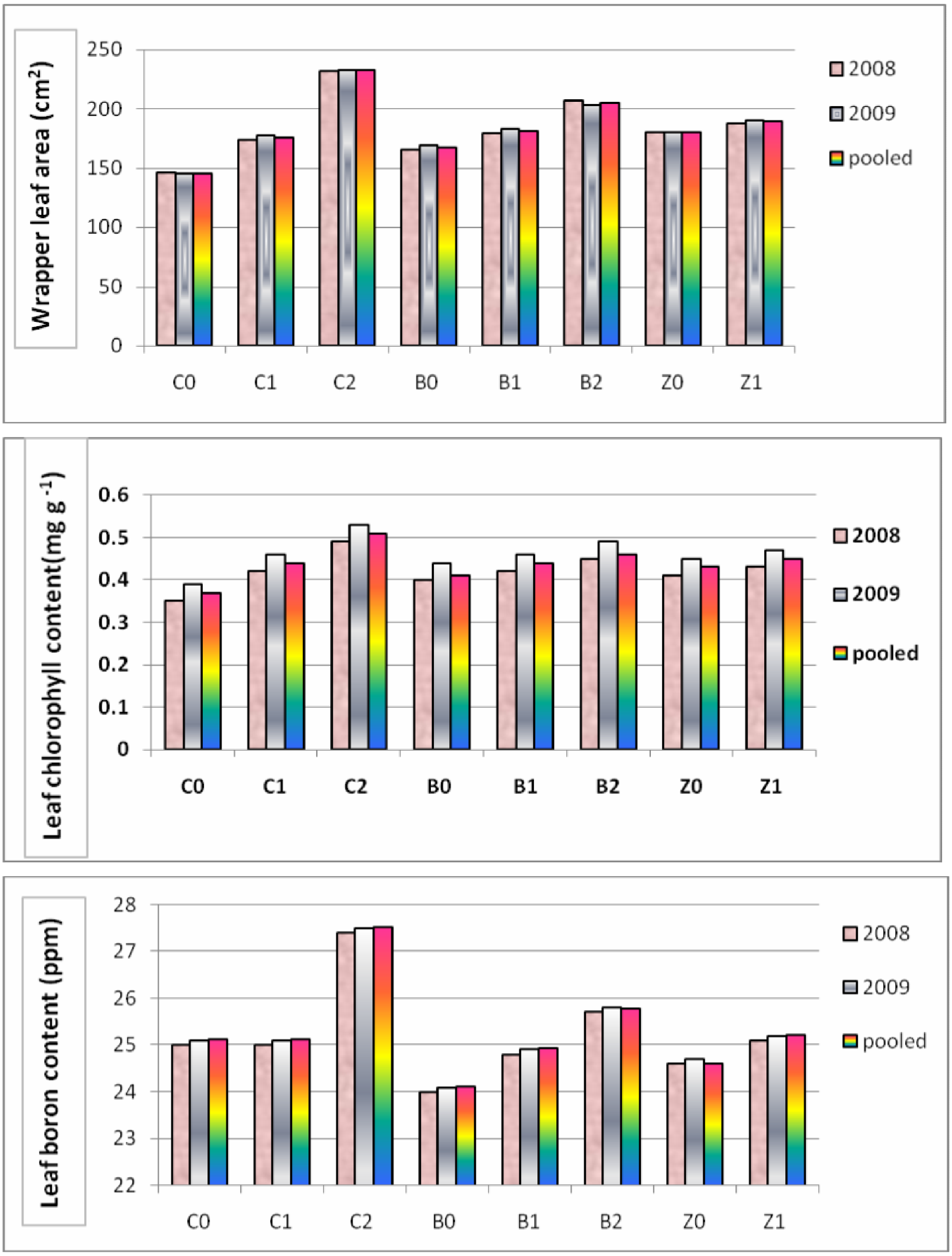


Fig. 2 : Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

calcium and zinc, the maximum (27.74 ppm) and minimum (21.83ppm) boron content was recorded under C_0Z_0 treatment combination.

The interaction between boron and zinc affected the leaf boron content. Highest leaf boron content (26.09 ppm) was recorded under B_2Z_1 followed by 25.45 ppm under B_2Z_0 and 25.19 ppm under B_1Z_1.

The interaction effect data (Table 4.1.6) revealed that different levels of calcium, boron and zinc caused significant variation in leaf boron content (Table 4.1.6). Interaction of $C_2B_2Z_1$ (calcium 10.00 kg × boron 1.00 kg × zinc 8.00 kg ha^{-1}) recorded the maximum boron content (28.30 ppm) followed by $C_2B_2Z_0$ (28.09 ppm) and $C_2B_1Z_1$ (27.87 ppm), whereas, the untreated plots ($C_0B_0Z_0$) recorded the minimum leaf boron content (20.89 ppm). The interactions between $C_2B_1Z_0$ and $C_2B_0Z_1$ were at par with 5 per cent level of significance.

4.1.1.9 Leaf Ca content (%)

Perusal of data on individual effects of Ca, B and Zn (Table 4.1.7 and Fig. 3) indicate that leaf calcium content attained the maximum value (5.52 %) in calcium 10.00 kg ha^{-1} whereas the lowest Ca content (4.47 %) was recorded in control. Application of boron from 0.5 to 1.00 kg ha^{-1} caused a significant improvement in leaf calcium content. Highest calcium content (5.13 %) was recorded with boron (1.00 kg ha^{-1}), whereas lowest calcium content (4.75 %) was recorded with 0.00 kg ha^{-1} boron. Similarly, increase in application of zinc from 0.00 to 8.00 kg ha^{-1} also registered improvement in leaf calcium content and resulted in calcium content (5.00 %).

The two-way interaction effects of data (Table 4.1.8) revealed that different combinations and levels caused significant variation in leaf calcium content. Calcium (10.00 kg ha^{-1}) supplied with boron (1.00 kg ha^{-1}) recorded the maximum leaf calcium content (5.79 %), whereas, the minimum leaf calcium content (4.38 %) was recorded with control (C_0 B_0).

The interaction between calcium and zinc also recorded significant impact on leaf calcium content. Calcium (10.00 kg ha^{-1}) applied with zinc (8.00 kg ha^{-1}) recorded significantly highest content of calcium (5.60 %) against the lowest leaf calcium content (4.41 %) in untreated control (C_0Z_0).

Boron in combination with zinc resulted in maximum leaf calcium content (5.18 %) in a treatment combination of boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) which was significantly superior to B_0Z_0 treatment combination producing lowest leaf calcium content of 4.67 %.

Calcium, boron and zinc interaction effect data (Table 4.1.9) revealed that different levels caused significant variation in leaf calcium content. Calcium (10.00 kg ha^{-1}) supplied with boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) recorded the highest content of calcium (5.85 %) in leaves followed by $C_2B_2Z_0$ (5.73 %), $C_2B_1Z_1$ (5.58 %) and $C_2B_1Z_0$ (5.46 %) whereas, calcium, boron and zinc applied at 0.00 kg ha^{-1} recorded the lowest content of calcium in leaves (4.25 %). The interactions between $C_1B_0Z_0$ and $C_0B_2Z_1$ were at par at 5 per cent level of significance.

4.1.1.10 Leaf zinc content (mg g^{-1})

The data on leaf zinc content in tulips as influenced by different calcium, boron and zinc nutrition are presented in Table 4.1.7 and Fig. 3 Application of these nutrients in individual significantly influenced the leaf Zn content. Increasing the level of calcium from 5.00 to 10.00 kg ha^{-1} increased the leaf Zn content. The highest content of zinc (26.77 mg g^{-1}) was recorded under calcium 10.00 kg ha^{-1}, followed by 26.20 mg g^{-1} under 5.00 kg ha^{-1} of Ca treatment.

The application of boron also proved to be beneficial in enhancing leaf Zn content. The highest content of leaf zinc (26.38 mg g^{-1}) was recorded under 1.00 kg boron (B_2) followed by 26.20 mg g^{-1} with 0.50 kg boron ha^{-1} (B_1) and lowest content of zinc (25.94 mg g^{-1}) was recorded under 0.00 kg boron application (control). However, B_1 and B_2 were statistically at par with each other (Table 4.1.7).

Application of zinc (8.00 kg ha^{-1}) caused a significant improvement in leaf zinc content with a value of 26.21 mg g^{-1} against the 21.13 mg g^{-1} in untreated control (0.00 kg ha^{-1}).

Data pertaining to the interaction effects of Ca × B, Ca × Zn and B × Zn are presented in Table 4.1.8 revealed that different nutrient and their levels caused marked variation in leaf zinc content. Calcium (10.00 kg ha^{-1}) supplied with boron (1.00 kg ha^{-1}) recorded the maximum leaf zinc content (26.92 mg g^{-1}), whereas, calcium (0.00 kg ha^{-1}) applied with boron (0.00 kg ha^{-1}) recorded the minimum leaf zinc content (25.23 mg g^{-1}). The interactions between C_2B_1 and C_2B_0 were at par with each other.

The interaction between calcium and zinc also recorded significant impact on leaf zinc content. Calcium (10.00 kg ha^{-1}) applied with zinc (8.00 kg ha^{-1}) recorded significantly highest content of zinc (26.80 mg g^{-1}), whereas, calcium (0.00 kg ha^{-1}) applied with zinc (0.00 kg ha^{-1}) recorded the lowest leaf zinc content (25.50 mg g^{-1}). However, C_2Z_1 and C_2Z_0 were statistically at par with each other (Table 4.1.8).

Boron in combination with zinc resulted in maximum zinc content (26.42 mg g^{-1}) in a treatment combination of B_2Z_1 which was significantly superior to B_0Z_0 treatment combination producing minimum leaf zinc content of 25.89 mg g^{-1}.

The interaction between calcium, boron and zinc recorded a similar trend with regard to the leaf zinc content (Table 4.1.9). $C_2B_2Z_1$ treatment combination resulted in maximum zinc content (26.96 mg g^{-1}) which was significantly superior over $C_0B_0Z_0$ treatment combination producing minimum leaf zinc content of 25.14 mg g^{-1}. However, $C_2B_1Z_1$ and $C_2B_1Z_0$ were statistically at par.

4.1.1.11 Petal membrane stability index (%)

Data presented in Table 4.1.7 and Fig. 3 reflected that the membrane stability index (MSI) responded to calcium application significantly. It appeared in the table that petal membrane stability increased with increasing level of Ca and attained the maximum value (55.34%) with the addition of calcium (10.00 kg ha^{-1}) whereas, the lowest petal membrane stability (52.57%) was recorded with calcium (0.00 kg ha^{-1}).

Application of boron also caused a significant improvement in petal membrane stability. Maximum membrane stability (54.35%) was recorded with 1.00 kg boron ha^{-1}, whereas minimum membrane stability (53.31%) was recorded with 0.00 kg B ha^{-1}. Similarly, application of Zn at 8.00 kg ha^{-1} also registered an improved petal membrane stability (53.97%) against the application of Zn at 0.00 kg ha^{-1} which resulted in minimum petal membrane stability (53.74 %).

It inferred from the study (Table 4.1.8) that interaction between any two factors resulted in a marked variation in MSI. Interactions of calcium and boron levels caused significant variation in petal membrane stability. Calcium (10.00 kg ha^{-1}) supplied with boron (1.00 kg ha^{-1}) recorded maximum membrane stability (56.10%), whereas, calcium (0.00 kg ha^{-1}) and boron (0.00 kg ha^{-1}) resulted in minimum petal membrane stability of 52.04 per cent.

The interaction between calcium and zinc also recorded significant impact on petal membrane stability. Calcium (10.00 kg ha^{-1}) with zinc (8.00 kg ha^{-1}) recorded significantly maximum membrane stability (55.49%), when compared with a 52.55 per cent MSI recorded under control (C_0Z_0).

Boron in combination with zinc resulted in maximum petal membrane stability (54.39%) in a treatment combination of B_2Z_1, which was significantly superior to B_0Z_0 treatment combination with least petal membrane stability (53.15%) (Table 4.1.8).

It was also inferred that combination of calcium, boron and zinc contributed more than their single applications (Table 4.1.9). Calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) combindly resulted in maximum

Table 4.1.7: Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

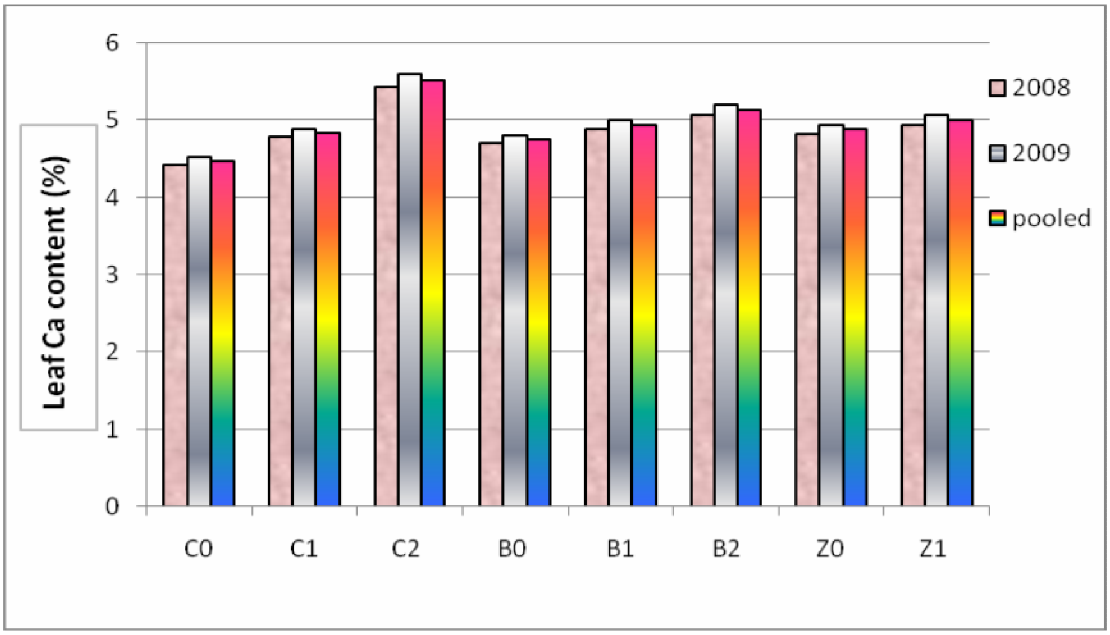
Treatment	Leaf Ca content (%)			Leaf Zn content (mg $^{-g}$)			Petal membrane stability index (%)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Calcium (kg ha^{-1})									
C_0 (0)	4.42	4.52	4.47	25.53	25.59	25.55	52.51	52.58	52.57
C_1 (5.00)	4.78	4.88	4.83	26.17	26.25	26.20	53.76	53.66	53.66
C_2 (10.00)	5.44	5.60	5.52	26.72	26.85	26.77	55.28	55.35	55.34
C.D$_{(P\leq0.05)}$	**0.006**	**0.007**	**0.006**	**0.05**	**0.07**	**0.05**	**0.26**	**0.24**	**0.24**
Boron (kg ha^{-1})									
B_0 (0)	4.70	4.81	4.75	25.91	25.99	25.94	53.30	53.31	53.31
B_1 (0.5)	4.88	5.00	4.94	26.17	26.26	26.20	53.74	53.92	53.91
B_2 (1.00)	5.06	5.20	5.13	26.35	26.45	26.38	54.51	54.35	54.35
C.D$_{(P\leq0.05)}$	**0.006**	**0.007**	**0.006**	**0.05**	**0.07**	**0.05**	**0.26**	**0.24**	**0.24**
Zinc (kg ha^{-1})									
Z_0 (0)	4.82	4.94	4.88	26.11	26.19	26.13	53.66	53.75	53.74
Z_1 (8.00)	4.94	5.06	5.00	26.18	26.28	26.21	54.04	53.98	53.97
C.D$_{(P\leq0.05)}$	**0.005**	**0.006**	**0.005**	**0.04**	**0.05**	**0.04**	**0.21**	**0.20**	**0.20**

Table 4.1.8 : Interaction effect of Ca x B, Ca x Zn and B x Zn on vegetative and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Leaf calcium (Ca) content (%)			Leaf Zinc (Zn) content (%)			Petal membrane stability index (%)		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Ca x B (kg ha^{-1})									
C_0B_0	4.28	4.38	4.33	25.22	25.27	25.23	52.03	52.04	52.04
C_0 B_1	4.45	4.55	4.50	25.61	25.68	25.63	52.35	52.71	52.67
C_0 B_2	4.55	4.65	4.60	25.77	25.82	25.78	53.15	52.99	52.99
C_1B_0	4.63	4.73	468	25.91	26.01	25.94	53.29	53.30	53.30
C_1 B_1	4.76	4.86	4.81	26.18	26.27	26.22	53.70	53.71	53.71
C_1 B_2	4.95	5.06	5.00	26.42	26.49	26.44	54.29	53.97	53.96
C_2 B_0	5.18	5.31	5.25	26.60	26.69	26.64	54.59	54.60	54.59
C_2 B_1	5.45	5.60	5.52	26.71	26.85	26.75	55.16	55.34	55.34
C_2 B_2	5.70	5.88	5.79	26.86	27.03	26.92	56.09	56.10	56.10
$CD_{(P\leq0.05)}$	**0.01**	**0.01**	**0.009**	**0.08**	**0.12**	**0.09**	**0.45**	**0.43**	**0.43**
Ca x Zn (kg ha^{-1})									
C_0Z_0	4.36	4.46	4.41	25.49	25.54	25.50	52.32	52.56	52.55
C_0Z_1	4.48	4.58	4.53	25.58	25.65	25.60	52.69	52.60	52.58
C_1Z_0	4.74	4.84	4.79	26.13	26.21	26.16	53.59	53.49	53.48
C_1Z_1	4.82	4.93	4.87	26.20	26.29	26.24	53.93	53.83	53.83
C_2Z_0	5.36	5.52	5.44	26.70	26.81	26.74	55.07	55.20	55.19
C_2Z_1	5.52	5.67	5.60	26.75	26.90	26.80	55.48	55.50	55.49
$CD_{(P\leq0.05)}$	**0.008**	**0.01**	**0.007**	**0.07**	**0.09**	**0.07**	**0.37**	**0.35**	**0.35**
B x Zn (kg ha^{-1})									
B_0 Z_0	4.62	4.73	4.67	25.87	25.93	25.89	53.03	53.15	53.15
B_0 Z_1	4.77	4.88	4.83	25.95	26.05	25.99	53.54	53.78	53.77
B_1 Z_0	4.84	4.95	4.90	26.13	26.23	26.16	53.57	53.47	53.47
B_1 Z_1	4.93	5.05	4.99	26.20	26.30	26.24	53.93	54.07	54.04
B_2 Z_0	5.01	5.14	5.07	26.32	26.40	26.34	54.41	54.32	54.31
B_2 Z_1	5.12	5.25	5.18	26.38	26.49	26.42	54.60	54.39	54.39
$CD_{(P\leq0.05)}$	**0.008**	**0.01**	**0.007**	**0.07**	**0.09**	**0.07**	**0.37**	**0.35**	**0.35**

Table 4.1.9: Combined effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Leaf calcium (Ca) content (%)			Leaf zinc (Zn) content (mg g^{-1})			Petal membrane stability index (%)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
C_0 B_0 Z_0	4.20	4.30	4.25	25.13	25.17	25.14	51.78	52.13	52.12
C_0 B_0 Z_1	4.36	4.46	4.41	25.31	25.38	25.33	52.12	52.46	52.46
C_0 B_1 Z_0	4.40	4.50	4.45	25.56	25.63	25.58	52.28	51.96	51.95
C_0 B_1 Z_1	4.50	4.60	4.55	25.66	25.73	25.68	52.58	52.96	52.89
C_0 B_2 Z_0	4.50	4.60	4.55	25.77	25.84	25.79	52.97	52.98	52.98
C_0 B_2 Z_1	4.60	4.70	4.65	25.77	25.81	25.78	53.07	53.09	53.08
C_1 B_0 Z_0	4.60	4.70	4.65	25.90	25.97	25.92	53.22	52.90	52.89
C_1 B_0 Z_1	4.66	4.76	4.71	25.91	26.04	25.96	53.57	53.58	53.57
C_1 B_1 Z_0	4.73	4.83	4.78	26.13	26.23	26.17	53.61	53.62	53.62
C_1 B_1 Z_1	4.80	4.90	4.85	26.23	26.30	26.27	53.84	53.85	53.850
C_1B_2 Z_0	4.90	5.00	4.95	26.37	26.44	26.39	54.23	53.91	53.90
C_1 B_2 Z_1	5.00	5.13	5.06	26.47	26.54	26.50	54.34	54.36	54.35
C_2 B_0 Z_0	5.06	5.20	5.13	26.57	26.64	26.61	54.35	54.03	54.02
C_2B_0 Z_1	5.30	5.43	5.36	26.64	26.74	26.67	54.83	54.84	54.84
C_2 B_1 Z_0	5.40	5.53	5.46	26.71	26.87	26.77	54.94	55.29	55.28
C_2 B_1 Z_1	5.50	5.66	5.58	26.71	26.82	26.74	55.38	55.39	55.39
C_2 B_2 Z_0	5.63	5.83	5.73	26.82	26.96	26.87	55.94	55.95	55.95
C_2 B_2 Z_1	5.76	5.93	5.85	26.90	27.10	26.96	56.24	56.25	56.25
$C.D_{(P\leq0.05)}$	**0.01**	**0.01**	**0.01**	**0.12**	**0.17**	**0.12**	**0.64**	**0.60**	**0.60**



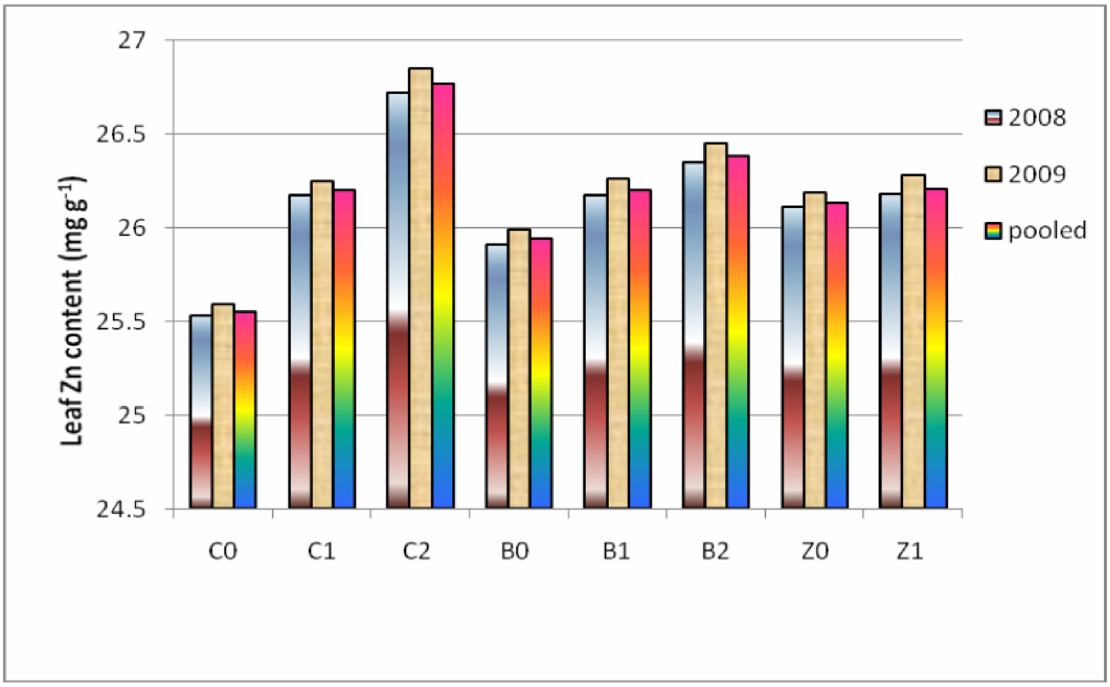


Fig. 3 : Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

petal membrane stability of 56.25 per cent followed by $C_2B_2Z_0$ (55.95 %) and $C_2B_1Z_1$ (55.39 %) against the minimum stability of 52.12% recorded in control.

4.1.1.12 Leaf nitrogen content (%)

Analysis of variance indicated that individual effects of calcium, boron and zinc and their levels thereof resulted in significant variation in leaf nitrogen content (Table 4.1.10 and Fig. 4).

Application of calcium significantly increased the level of leaf nitrogen. Calcium at 10.00 kg ha^{-1} recorded maximum (2.80%) nitrogen content followed by 2.75 per cent leaf nitrogen in Ca (5.00 kg ha^{-1}) while minimum nitrogen content (2.68%) was recorded under calcium (0.00 kg ha^{-1}).

Perusal of mean values for leaf nitrogen content under different boron levels revealed that application of boron had a significant positive impact on leaf nitrogen content. The highest nitrogen content (2.77%) was observed under 1.00 kg ha^{-1} and lowest (2.72%) leaf nitrogen content was observed under 0.00 kg ha^{-1} of boron.

Application of zinc (8.00 kg ha^{-1}) registered a significant increase in leaf nitrogen content. The leaf nitrogen content of zinc applied plots was observed as 2.75 % against the 2.74 % leaf nitrogen in untreated control plots.

The interaction effect data of two factors (Table 4.1.11) clearly indicated that there was a marked increase in leaf nitrogen content and with the increase in rate of application of calcium and boron there occurred a corresponding increase in nitrogen content. The leaf nitrogen content was highest (2.82%) under C_2B_2 followed by 2.80 per cent under C_2B_1 and minimum (2.65%) recorded under C_0B_0. However, the interactions between C_2B_1, C_2B_0 and C_1B_2 were statistically at par with each other.

The interaction between calcium and zinc significantly affected the leaf nitrogen content. Highest nitrogen content (2.81%) was recorded under C_2Z_1

followed by 2.79 per cent under C_2Z_0 and minimum nitrogen content (2.67%) was recorded under C_0Z_0.

Though the leaf nitrogen content was influenced by the interaction between boron and zinc, yet these interactive influences were statistically at par with each other (Table 4.1.11).

Pooled data of three way interaction (Table 4.1.12) revealed that among different calcium, boron and zinc levels, combined application of calcium (10.00 kg ha^{-1}) × boron (1.00 kg ha^{-1}) × zinc (8.00 kg ha^{-1}) registered significantly higher nitrogen content (2.83%) in leaves against the control (2.66 %). The highest nitrogen content (2.83 %) in $C_2B_2Z_1$ was followed in decreasing order by $C_2B_2Z_0$ (2.81%), $C_2B_1Z_1$ (2.80%) and $C_2B_1Z_0$ (2.79%).

4.1.1.13 Leaf phosphorus content (%)

The data on leaf phosphorus content in tulips as influenced by different nutrients are presented in Table 4.1.10 and Fig. 4. In plants treated with calcium at 10.00 kg ha^{-1} indicated highest leaf phosphorus content (0.74%) and the lowest (0.67%) was recorded in untreated plants.

Application of boron produced similar effects, depicting maximum leaf phosphorus (0.72%) with the application of boron at 1.00 kg ha^{-1} followed by (0.71%) with 0.5 kg B ha^{-1} and minimum (0.70%) was with boron 0.00 kg ha^{-1}.

The influence of zinc on leaf phosphorus content depicted that leaf phosphorus was also affected significantly with zinc and maximum content of 0.72 per cent was recorded with 8.00 kg Zn ha^{-1} against the Z_0 (0.70%) (Table 4.1.10).

The interaction effects of any two factors are presented in Table 4.1.11. The influence of interaction between calcium and boron levels in terms of leaf phosphorus content was significant. Maximum content (0.76%) was observed in C_2B_2 i.e., 10.00 kg ha^{-1} of calcium and 1.00 kg ha^{-1} of boron. Whereas, minimum content of 0.66 per cent was recorded with calcium and boron at 0.00 kg ha^{-1}. The interactions between C_2B_1 and C_2B_0 were statistically at par with each other.

The interaction between calcium and zinc also influenced the leaf phosphorus content with highest content (0.75%) recorded under calcium (10.00 kg ha^{-1}) plus zinc (8.00 kg ha^{-1}), whereas, the minimum (0.67%) was recorded under Ca and Zn at 0.00 kg ha^{-1}.

Data further revealed that significantly maximum phosphorus content (0.72%) was recorded under the influence of interaction between boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) followed by 0.72% under B_2Z_0.

A favourable interaction of different levels of all nutrients was also observed in the present study (Table 4.1.12). Highest leaf phosphorus content (0.76%) was recorded with highest level of calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) followed by $C_2B_1Z_0$ (0.75%) and $C_2B_0Z_1$ (0.74%) as compared with the lowest leaf phosphorus content of 0.66 per cent with zero level of Ca, B and Zn. However, $C_2B_2Z_0$ and $C_2B_1Z_1$ were statistically at par with each other (Table 4.1.12).

4.1.1.14 Leaf potassium content (%)

Data on leaf potassium content as influenced by different levels of calcium, boron and zinc are summarised in Table 4.1.10 and Fig. 4. Maximum leaf potassium (3.00%) was recorded under the application of calcium (10.00 kg ha^{-1}) whereas the minimum leaf potassium content (2.90%) was recorded under C_0 (control).

The application of boron had a significant impact on leaf potassium content. Maximum leaf potassium content (2.97%) was produced under boron at 1.00 kg ha^{-1}, whereas, the minimum potassium content (2.93%) was recorded under boron at zero kg ha^{-1} (Table 4.1.10).

Zinc applied at 8.00 kg ha^{-1} registered a marked increase in leaf potassium content (2.96%) as compared with a leaf potassium content of 2.94% in untreated control.

The interaction of Ca × B, Ca × Zn and B × Zn also had significant influence on leaf potassium content in tulip (Table 4.1.11). The combined application of calcium and boron levels proved to be beneficial in improving the leaf potassium content. The treatment combination C_2B_2 (Ca 10.00 kg ha^{-1} × B 1.00 kg ha^{-1}) recorded the highest leaf potassium of 3.02 per cent. This was followed by the application of calcium at 10.00 kg plus boron at 0.5 kg ha^{-1} which resulted in a leaf potassium content of 3.01 per cent. Minimum leaf potassium (2.88%) was, however, recorded at zero kg ha^{-1} of calcium and boron each.

The interaction between calcium and zinc levels again proved to be instrumental in improving the leaf potassium content. The treatment combination C_2Z_1 (Ca 10.00 kg ha^{-1} × Zn 8.00 kg ha^{-1}) recorded the highest content of leaf potassium (3.01%) whereas, the lowest content of 2.90 per cent was recorded under C_0Z_0 treatment combination.

Leaf potassium altered significantly due to different levels of boron and zinc as well. Tulip plants receiving 1.00 kg boron ha^{-1} and 8.00 kg zinc ha^{-1} showed maximum leaf potassium content (2.97%) followed by 0.5 kg ha^{-1} boron application which produced 2.96 per cent leaf potassium content, whereas, lower content (2.92%) was recorded under 0.00 kg ha^{-1} of boron and zinc.

Most of other interactions of two factors were, however, statistically at par with each other in respect of leaf potassium content (Table 4.1.11).

The interaction effect data (Table 4.1.12) clearly indicated that with the increase in rate of application of calcium, boron and zinc these occurred a corresponding increase in leaf potassium content. The leaf potassium was highest (3.03%) under $C_2B_2Z_1$ followed by 3.02 under $C_2B_2Z_0$ and 3.01 per cent under $C_2B_1Z_{1,}$ whereas, lowest potassium content (2.87 %) was recorded under $C_0B_0Z_0$ treatment combination. However, the interactions between $C_2B_1Z_1$ and $C_2B_1Z_0$ were statistically at par at five per cent level of significance.

Table 4.1.10: Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Leaf Nitrogen content (%)			Leaf phosphorus content (%)			Leaf potassium content (%)		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Calcium (kg ha^{-1})									
C_0 (0)	2.63	2.64	2.68	0.67	0.68	0.67	2.90	2.91	2.90
C_1 (5.00)	2.70	2.72	2.75	0.71	0.72	0.72	2.94	2.95	2.95
C_2 (10.00)	2.79	2.81	2.80	0.73	0.75	0.74	3.00	3.01	3.00
C.D$_{(P\leq0.05)}$	**0.009**	**0.01**	**0.009**	**0.007**	**0.005**	**0.004**	**0.009**	**0.014**	**0.01**
Boron (kg ha^{-1})									
B_0 (0)	2.67	2.69	2.72	0.70	0.71	0.70	2.93	2.93	2.93
B_1 (0.5)	2.71	2.72	2.74	0.71	0.72	0.71	2.95	2.96	2.95
B_2 (1.00)	2.74	2.76	2.77	0.71	0.73	0.72	2.96	2.97	2.97
C.D$_{(P\leq0.05)}$	**0.009**	**0.01**	**0.009**	**0.007**	**0.005**	**0.004**	**0.009**	**0.014**	**0.01**
Zinc (kg ha^{-1})									
Z_0 (0)	2.70	2.72	2.74	0.70	0.71	0.70	2.94	2.95	2.94
Z_1 (8.00)	2.72	2.73	2.75	0.71	0.73	0.72	2.95	2.96	2.96
C.D$_{(P\leq0.05)}$	**0.008**	**0.008**	**0.008**	**0.006**	**0.004**	**0.003**	**0.007**	**0.005**	**0.008**

Table 4.1.11 : Interaction effect of Ca x B, Ca x Zn and B x Zn on vegetative and physiological characters of tulip c v. Apeldoorn (2008-09 to 2009-10)

Treatment	Leaf Nitrogen content (%)			Leaf Phosphorus content (%)			Leaf Potassium content (%)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Ca x B (kg ha^{-1})									
C_0B_0	2.60	2.70	2.65	0.67	0.66	0.66	2.88	2.88	2.88
$C_0 B_1$	2.63	2.73	2.68	0.67	0.68	0.67	2.91	2.91	2.91
$C_0 B_2$	2.66	2.76	2.71	0.67	0.69	0.68	2.92	2.92	2.92
C_1B_0	2.68	2.78	2.73	0.70	0.71	0.70	2.93	2.94	2.93
$C_1 B_1$	2.70	2.81	2.76	0.72	0.73	0.72	2.94	2.95	2.94
$C_1 B_2$	2.72	2.83	2.78	0.72	0.73	0.72	2.96	2.97	2.97
$C_2 B_0$	2.73	2.84	2.78	0.73	0.75	0.74	2.98	2.98	2.98
$C_2 B_1$	2.74	2.85	2.80	0.73	0.75	0.74	3.00	3.01	3.01
$C_2 B_2$	2.77	2.88	2.82	0.75	0.77	0.76	3.01	3.03	3.02
$CD_{(P\leq0.05)}$	**0.06**	**0.14**	**0.10**	**0.01**	**0.009**	**0.01**	**0.01**	**0.02**	**0.01**
Ca x Zn (kg ha^{-1})									
C_0Z_0	2.62	2.72	2.67	0.66	0.68	0.67	2.89	2.90	2.90
C_0Z_1	2.64	2.74	2.69	0.67	0.68	0.68	2.91	2.91	2.91
C_1Z_0	2.70	2.80	2.75	0.71	0.72	0.72	2.94	2.95	2.94
C_1Z_1	2.70	2.81	2.76	0.71	0.72	0.71	2.95	2.96	2.95
C_2Z_0	2.74	2.85	2.79	0.73	0.75	0.74	2.99	3.00	3.00
C_2Z_1	2.75	2.86	2.81	0.74	0.76	0.75	3.00	3.02	3.01
$CD_{(P\leq0.05)}$	**0.05**	**0.11**	**0.08**	**0.009**	**0.007**	**0.006**	**0.01**	**0.02**	**0.01**
B x Zn (kg ha^{-1})									
$B_0 Z_0$	2.66	2.77	2.72	0.69	0.70	0.69	2.92	2.92	2.92
$B_0 Z_1$	2.67	2.78	2.73	0.70	0.72	0.71	2.94	2.95	2.94
$B_1 Z_0$	2.69	2.79	2.74	0.70	0.71	0.71	2.95	2.97	2.96
$B_1 Z_1$	2.70	2.80	2.75	0.71	0.73	0.72	2.95	2.95	2.95
$B_2 Z_0$	2.71	2.82	2.76	0.71	0.72	0.71	2.96	2.97	2.96
$B_2 Z_1$	2.72	2.83	2.78	0.72	0.73	0.72	2.97	2.98	2.97
$CD_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.009**	**0.007**	**0.006**	**0.01**	**0.02**	**0.01**

Table 4.1.12: Combined effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Leaf nitrogen content (%)			Leaf Phosphorus content (%)			Leaf Potassium content (%)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
C_0 B_0 Z_0	2.59	2.60	2.66	0.66	0.66	0.66	2.87	2.87	2.87
C_0 B_0 Z_1	2.59	2.60	2.64	0.67	0.69	0.68	2.90	2.91	2.90
C_0 B_1 Z_0	2.62	2.63	2.67	0.67	0.69	0.68	2.90	2.89	2.90
C_0 B_1 Z_1	2.64	2.65	2.70	0.67	0.68	0.67	2.91	2.92	2.91
C_0 B_2 Z_0	2.66	2.67	2.71	0.68	0.70	0.69	2.92	2.93	2.92
C_0 B_2 Z_1	2.67	2.69	2.73	0.68	0.66	0.67	2.92	2.92	2.92
C_1 B_0 Z_0	2.67	2.68	2.72	0.69	0.70	0.70	2.93	2.94	2.94
C_1 B_0 Z_1	2.68	2.70	2.74	0.71	0.71	0.71	2.93	2.94	2.93
C_1 B_1 Z_0	2.70	2.72	2.75	0.72	0.73	0.73	2.94	2.95	2.94
C_1 B_1 Z_1	2.71	2.73	2.76	0.72	0.73	0.72	2.94	2.95	2.94
C_1B_2 Z_0	2.72	2.74	2.77	0.72	0.73	0.72	2.95	2.97	2.96
C_1 B_2 Z_1	2.73	2.75	2.78	0.72	0.73	0.72	2.97	2.96	2.97
C_2 B_0 Z_0	2.74	2.76	2.78	0.72	0.73	0.72	2.97	2.98	2.97
C_2B_0 Z_1	2.76	2.78	2.79	0.73	0.75	0.74	2.99	3.01	3.00
C_2 B_1 Z_0	2.78	2.80	2.79	0.73	0.76	0.75	3.00	3.01	3.00
C_2 B_1 Z_1	2.81	2.83	2.80	0.74	0.75	0.74	3.00	3.02	3.01
C_2 B_2 Z_0	2.83	2.85	2.81	0.74	0.77	0.76	3.01	3.02	3.02
C_2 B_2 Z_1	2.85	2.86	2.83	0.75	0.77	0.76	3.02	3.03	3.03
$C.D_{(P\leq0.05)}$	**NS**	**0.20**	**0.14**	**0.01**	**0.01**	**0.01**	**0.02**	**0.03**	**0.02**

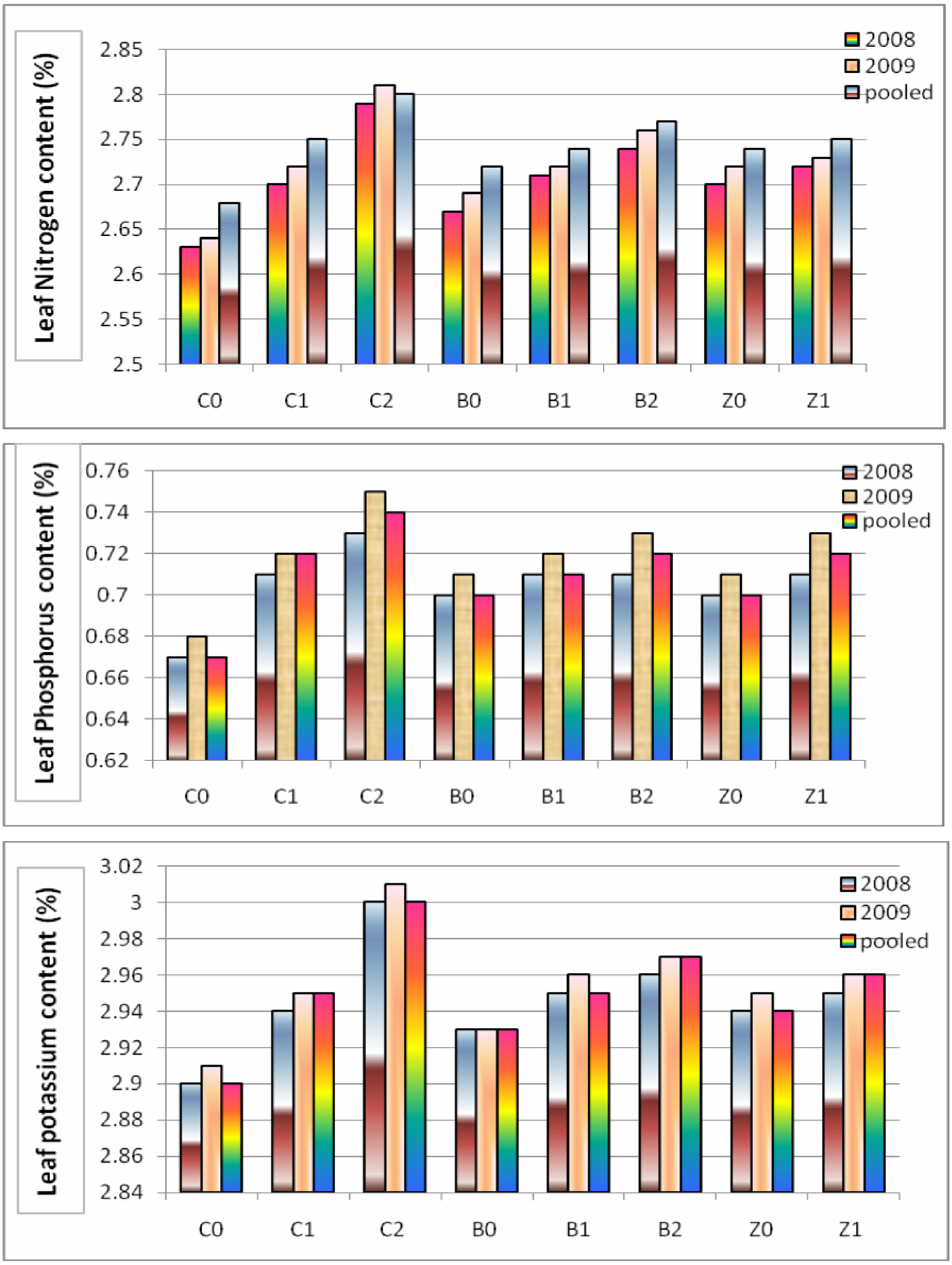


Fig. 4 : Effect of Ca, B and Zn on growth and physiological characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

4.2 Flowering characteristics

4.2.1 Days taken to appearance of flower bud

The time taken to appearance of flower bud after the planting of bulbs as influenced by calcium, boron and zinc are presented in Table 4.2.1 and Fig. 5.

Days taken to appearance of flower bud was markedly influenced by the application of different nutrients. Less number of days (104.11) was taken for flower bud appearance in calcium (10.00 kg ha^{-1}) as compared with 113.76 days in calcium (0.00 kg ha^{-1}) treated plants.

An examination of the data further indicated that the differences in days taken to flower bud appearance due to various levels of boron were highly significant. Minimum days (107.69) required for appearance of flower bud were noticed under 1.00 kg ha^{-1} of boron application followed by 0.50 kg ha^{-1} (110.18) while maximum days (111.18) was recorded under the lowest level of boron i.e. 0.00 kg ha^{-1}. The application of zinc at 8.00 kg ha^{-1} resulted in significantly less number of days taken to appearance of flower bud (109.19) in comparison to days required by plants supplied with 0.00 kg ha^{-1} of zinc (110.17 day).

The interaction between two factors of these nutrients and their levels exhibited a significant variation in days taken to flower bud appearance. So far as interaction of Ca and B is concerned, the highest number of days taken to appearance of flower bud (114.8) was recorded in C_0B_0 treatment as compared with the minimum number of days taken (100.47) under C_2B_2 treatment combination (Table 4.2.2).

The interactive influence between calcium and zinc levels on the days taken to appearance of flower bud was also significant. Lesser number of days (103.05) was recorded under C_2Z_2 treatment combination, whereas, more number of days (114.19) was required for appearance of flower bud in C_0Z_0 treatment combination.

Interaction of boron x zinc were also significant with regard to appearance of flower bud. Minimum number of days (106.79) was recorded under B_2Z_1 treatment combination and the highest number of days (111.82) was recorded under B_0Z_0 treatment combination.

The interaction between various levels of calcium, boron and zinc also exhibited a significant variation on the days taken to appearance of flower bud (Table 4.2.3). The highest number of days (114.33) taken to bud appearance was noticed under $C_0B_0Z_0$ treatment combination, whereas, the lowest (99.38 day) was recorded under $C_2B_2Z_1$ treatment combination. The lowest number of days taken to bud appearance in $C_2B_2Z_1$ was followed in ascending order by $C_2B_2Z_0$ (102.42 day), $C_2B_1Z_1$ (104.73 day) and $C_2B_1Z_0$ (104.82 day).

4.2.2 Bud blast (%)

Perusal of the data pertaining to bud blast revealed that Ca, B and Zn applications had remarkable influence on this particular character in tulip (Table 4.2.1 and Fig. 5). So far as Ca is concerned the minimum bud blast (1.09%) was recorded in calcium 10.00 kg ha^{-1} while maximum bud blast (6.00%) was recorded under calcium 0.00 kg ha^{-1}.

The per cent of bud blasted plants registered under different levels of boron differed statistically at 5 per cent level of significance. The lowest per cent of bud blast (2.66%) was observed under boron 1.00 kg ha^{-1} and highest (4.66%) was recorded under 0.00 kg ha^{-1} of boron which was almost double than boron 1.00 kg ha^{-1}.

Application of zinc produced similar effects, depicting minimum per cent of bud blast (3.60%) with the application of zinc at 8.00 kg ha^{-1}. This was statistically lower than zinc 0.00 kg ha^{-1} which recorded (3.81%) bud blast.

Table-4.2.2 reflects the two-way interaction effects of Ca, B and Zn on bud blast per cent in tulip. The interaction between calcium and boron levels in terms of bud blast were significant. No bud blast was recorded with the interaction between calcium 10.00 kg ha^{-1} and boron at 1.00 kg ha^{-1} (C_2B_2) while 7.50% bud blast was observed under calcium and boron at 0.00 kg ha^{-1} each (C_0B_0).

The interaction between calcium and zinc also influenced the bud blast per cent significantly. Minimum bud blast (0.83%) was recorded for calcium at 10.00 kg ha^{-1} and zinc at 8.00 kg ha^{-1} (C_2Z_1) and the maximum bud blast (6.58%) was observed in calcium 0.00 kg ha^{-1} with zinc 0.00 kg ha^{-1}. However C_1Z_1 was statistically at par with C_1Z_0.

Data further revealed significantly minimum bud blast (2.80%) under the influence of boron 1.00 kg ha^{-1} and zinc at 8.00 kg ha^{-1} (B_2Z_1) whereas, the maximum bud blast (5.16%) was recorded under boron at 0.00 kg ha^{-1} along with zinc 0.00 kg ha^{-1} (B_0Z_0).

Perusal of the data (Table-4.2.3) revealed that combined application of calcium, boron and zinc at 10.00, 1.00 and 8.00 kg ha^{-1}, respectively recorded no bud blast. Influence of $C_2B_2Z_0$ and $C_2B_1Z_1$ also showed no bud blast whileas, maximum bud blast (6.50%) was recorded under the treatment combination of $C_0B_0Z_0$.

4.2.3 Days taken to colour break

The perusal of mean values for days to colour break (Table-4.2.1) under the influence of three nutrients indicated a significant variation in days taken to colour break. The minimum number of days to colour break (7.38) was recorded in calcium at 10.00 kg ha^{-1} and maximum days to colour break (7.76) in calcium at 0.00 kg ha^{-1}.

Boron application also influenced the days to colour break significantly. Increase in the application of boron from 0.50 to 1.00 kg ha^{-1} decreased the days taken to colour break from 7.58 days to 7.47 days as compared to 7.65 days under zero level of boron application.

Application of zinc produced similar effects, depicting minimum number of days (7.53) to colour break with the application of zinc at 8.00 kg ha^{-1}. This was statistically different from the lowest level of zinc (0.00 kg ha^{-1}) with 7.60 days to colour break.

Data on interaction effects of two nutrients are presented in Table-4.2.2. The influence of interaction between calcium and boron levels in terms of days to colour break were significant. Minimum days to colour break (7.25) was observed in treatment combination of C_2B_2 with calcium 10.00 kg ha^{-1} and boron 1.00 kg ha^{-1} followed in ascending order by 7.44 days in C_2B_1, 7.45 days in C_2B_0 and 7.49 days in C_1B_2, whereas, maximum days (7.88) to colour break was recorded under treatment combination C_0B_0 with 0.00 kg ha^{-1} each of calcium and boron.

Perusal of data revealed that application of calcium 10.00 kg ha^{-1} with zinc 8.00 kg ha^{-1} resulted in minimum days 7.33 to colour break in comparison to C_0Z_0 which took 7.80 days to colour break.

Boron in combination with zinc further revealed significantly minimum number of days to colour break (7.41) with treatment combination of B_2Z_1, whereas maximum (7.68 day) were taken to colour break with the treatment combination of B_0Z_0.

The influence of interaction between different levels of calcium, boron and zinc in terms of days to colour break were also significant (Table 4.2.3). Minimum number of days (7.13) was observed with treatment combination of $C_2B_2Z_1$ with calcium 10.00 kg ha^{-1}, boron 1.00 kg ha^{-1} and zinc 8.00 kg ha^{-1}, whereas, maximum days (7.93) to colour break was recorded under the treatment combination of $C_0B_0Z_0$ at 0.00 kg ha^{-1} calcium, boron and zinc each, respectively.

4.2.4 Days to flower opening

The time taken to flower opening after the appearance of flower bud in tulip as influenced by calcium, boron and zinc are presented in Table-4.2.1 and Fig. 5.

Less number of days (5.00) was taken for flower opening under Ca 10 kg ha^{-1} compared to as high as 5.97 days under zero level of calcium.

Table 4.2.1: Effect of Ca, B and Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Days taken to appearance of flower bud			Bud blasting (%)			Days to colour break			Days to flower opening		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Calcium (kg ha^{-1})												
C_0 (0)	113.49	114.03	113.76	6.69	5.30	6.00	7.70	7.83	7.76	6.00	5.94	5.97
C_1 (5.00)	110.81	111.54	111.18	4.44	3.61	4.02	7.46	7.66	7.56	5.66	5.16	5.41
C_2 (10.00)	104.22	103.99	104.11	1.23	0.95	1.09	7.27	7.49	7.38	5.00	5.00	5.00
C.D$_{(P\leq0.05)}$	**0.50**	**0.49**	**0.35**	**0.40**	**0.46**	**0.29**	**0.08**	**0.03**	**0.05**	**0.20**	**0.18**	**0.11**
Boron (kg ha^{-1})												
B_0 (0)	110.74	111.61	111.18	5.00	4.33	4.66	7.57	7.73	7.65	5.66	5.50	5.58
B_1 (0.5)	110.16	110.21	110.18	4.53	3.03	3.78	7.48	7.68	7.58	5.55	5.33	5.44
B_2 (1.00)	107.63	107.75	107.69	2.83	2.50	2.66	7.37	7.56	7.47	5.44	5.27	5.36
C.D$_{(P\leq0.05)}$	**0.50**	**0.49**	**0.35**	**0.40**	**0.46**	**0.29**	**0.08**	**0.03**	**0.05**	**NS**	**NS**	**NS**
Zinc (kg ha^{-1})												
Z_0 (0)	109.92	110.42	110.17	4.28	3.34	3.81	7.51	7.69	7.60	5.55	5.37	5.46
Z_1 (8.00)	109.10	109.29	109.19	3.96	3.24	3.60	7.44	7.62	7.53	5.55	5.37	5.46
C.D$_{(P\leq0.05)}$	**0.41**	**0.40**	**0.28**	**0.13**	**0.18**	**0.20**	**0.06**	**0.03**	**0.04**	**NS**	**NS**	**NS**

Table 4.2.2 : Interaction effect of Ca x B, Ca x Zn and B x Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Days taken to appearance of floral bud			Bud blasting (%)			Days to colour break			Days to flower opening		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Ca x B (kg ha^{-1})												
C_0B_0	114.27	115.33	114.80	7.50	7.50	7.50	7.83	7.93	7.88	6.00	6.00	6.00
C_0 B_1	113.70	114.55	114.12	7.41	6.00	6.70	7.66	7.83	7.75	6.00	6.00	6.00
C_0 B_2	112.68	113.23	112.95	5.25	5.00	5.12	7.60	7.73	7.66	6.00	6.00	6.00
C_1B_0	111.83	112.38	112.10	5.08	5.00	5.04	7.56	7.70	7.63	6.00	6.00	6.00
C_1 B_1	110.90	111.73	111.31	5.00	4.16	4.58	7.46	7.66	7.57	6.00	5.83	5.91
C_1 B_2	109.52	109.63	109.57	4.16	2.91	3.54	7.36	7.61	7.49	6.00	5.83	5.91
C_2 B_0	108.23	106.68	107.45	2.91	2.50	2.70	7.33	7.58	7.45	6.00	5.50	5.75
C_2 B_1	104.17	104.08	104.12	1.20	0.36	0.78	7.33	7.55	7.44	5.66	5.00	5.33
C_2 B_2	100.27	100.67	100.47	0.00	0.00	0.00	7.16	7.35	7.25	5.33	5.00	5.16
$CD_{(P\leq0.05)}$	**0.45**	**0.82**	**0.60**	**0.82**	**0.94**	**0.59**	**0.14**	**0.06**	**0.10**	**NS**	**NS**	**0.008**
Ca x Zn (kg ha^{-1})												
C_0Z_0	113.79	114.59	114.19	6.77	6.38	6.58	7.73	7.86	7.80	6.00	6.00	6.00
C_0Z_1	113.31	114.16	113.73	6.66	5.94	6.30	7.66	7.80	7.73	6.00	5.88	5.94
C_1Z_0	111.03	111.86	111.44	4.77	4.16	4.47	7.51	7.66	7.58	5.66	5.22	5.44
C_1Z_1	110.47	110.64	110.55	4.72	3.88	4.30	7.42	7.65	7.53	5.66	5.11	5.38
C_2Z_0	105.00	104.97	104.98	1.91	1.07	1.49	7.31	7.55	7.43	5.00	5.00	5.00
C_2Z_1	103.44	102.66	103.05	0.83	0.83	0.83	7.24	7.43	7.33	5.00	5.00	5.00
$CD_{(P\leq0.05)}$	**0.42**	**0.67**	**0.49**	**0.67**	**0.76**	**0.48**	**0.11**	**0.06**	**0.08**	**NS**	**NS**	**0.01**
B x Zn (kg ha^{-1})												
B_0 Z_0	111.71	111.93	111.82	5.33	5.00	5.16	7.62	7.75	7.68	5.66	5.55	5.61
B_0 Z_1	111.18	111.00	111.09	5.00	5.00	5.00	7.53	7.72	7.62	5.66	5.44	5.55
B_1 Z_0	109.83	110.68	110.25	4.96	3.85	4.41	7.51	7.70	7.60	5.55	5.33	5.44
B_1 Z_1	109.34	109.57	109.45	4.11	3.16	3.63	7.46	7.66	7.56	5.55	5.33	5.44
B_2 Z_0	108.28	108.80	108.54	3.16	2.77	2.97	7.42	7.63	7.52	5.44	5.33	5.38
B_2 Z_1	106.70	106.89	106.79	3.11	2.50	2.80	7.33	7.50	7.41	5.44	5.22	5.33
$CD_{(P\leq0.05)}$	**0.42**	**0.67**	**0.49**	**0.67**	**0.76**	**0.48**	**0.11**	**0.06**	**0.08**	**NS**	**NS**	**0.01**

NS = Non - significant

Table 4.2.3: Combined effect of Ca, B and Zn on floral characters of tulip cv. Apeldoorn (2008-09to 2009-10)

Treatment	Days taken to appearance of floral bud			Bud blasting (%)			Days to colour break			Days to flower opening		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
C_0 B_0 Z_0	114.53	114.13	114.33	7.50	5.50	6.50	7.93	7.93	7.93	6.00	6.00	6.00
C_0 B_0 Z_1	113.77	115.53	114.65	7.50	5.50	6.50	7.73	7.60	7.66	6.00	6.00	6.00
C_0 B_1 Z_0	113.40	114.97	114.18	7.50	5.50	6.50	7.66	7.73	7.70	6.00	6.00	6.00
C_0 B_1 Z_1	113.23	112.20	112.72	7.33	5.33	6.33	7.66	7.86	7.76	6.00	6.00	6.00
C_0 B_2 Z_0	113.07	115.13	114.10	5.33	5.00	5.16	7.60	7.83	7.71	6.00	6.00	6.00
C_0 B_2 Z_1	112.97	112.23	112.60	5.00	3.33	4.16	7.60	7.90	7.75	6.00	5.66	5.83
C_1 B_0 Z_0	111.93	113.17	112.55	5.00	3.33	4.16	7.60	7.70	7.65	6.00	5.66	5.83
C_1 B_0 Z_1	111.73	113.20	112.47	5.00	5.00	5.00	7.53	7.70	7.61	6.00	5.33	5.66
C_1 B_1 Z_0	111.47	112.03	111.75	5.00	5.00	5.00	7.53	7.70	7.61	5.66	5.00	5.33
C_1 B_1 Z_1	110.67	111.87	111.27	5.00	5.00	5.00	7.40	7.66	7.53	5.66	5.00	5.33
C_1B_2 Z_0	110.03	111.03	110.53	3.33	2.50	2.91	7.40	7.66	7.53	5.33	5.00	5.16
C_1 B_2 Z_1	109.00	107.97	108.48	3.33	2.50	2.91	7.33	7.63	7.48	5.33	5.00	5.16
C_2 B_0 Z_0	108.67	107.97	108.32	2.50	2.50	2.50	7.33	7.60	7.46	5.00	5.00	5.00
C_2B_0 Z_1	107.80	102.13	104.97	2.50	2.50	2.50	7.33	7.60	7.46	5.00	5.00	5.00
C_2 B_1 Z_0	104.53	105.10	104.82	2.40	0.73	1.56	7.33	7.56	7.45	5.00	5.00	5.00
C_2 B_1 Z_1	103.80	105.67	104.73	0.00	0.00	0.00	7.33	7.53	7.43	5.00	5.00	5.00
C_2 B_2 Z_0	101.80	103.03	102.42	0.00	0.00	0.00	7.26	7.50	7.38	5.00	5.00	5.00
C_2 B_2 Z_1	98.73	100.03	99.38	0.00	0.00	0.00	7.06	7.20	7.13	5.00	5.00	5.00
C.D$_{(P\leq0.05)}$	**0.73**	**1.16**	**0.86**	**0.99**	**1.15**	**0.73**	**0.20**	**0.09**	**0.14**	**NS**	**NS**	**0.02**

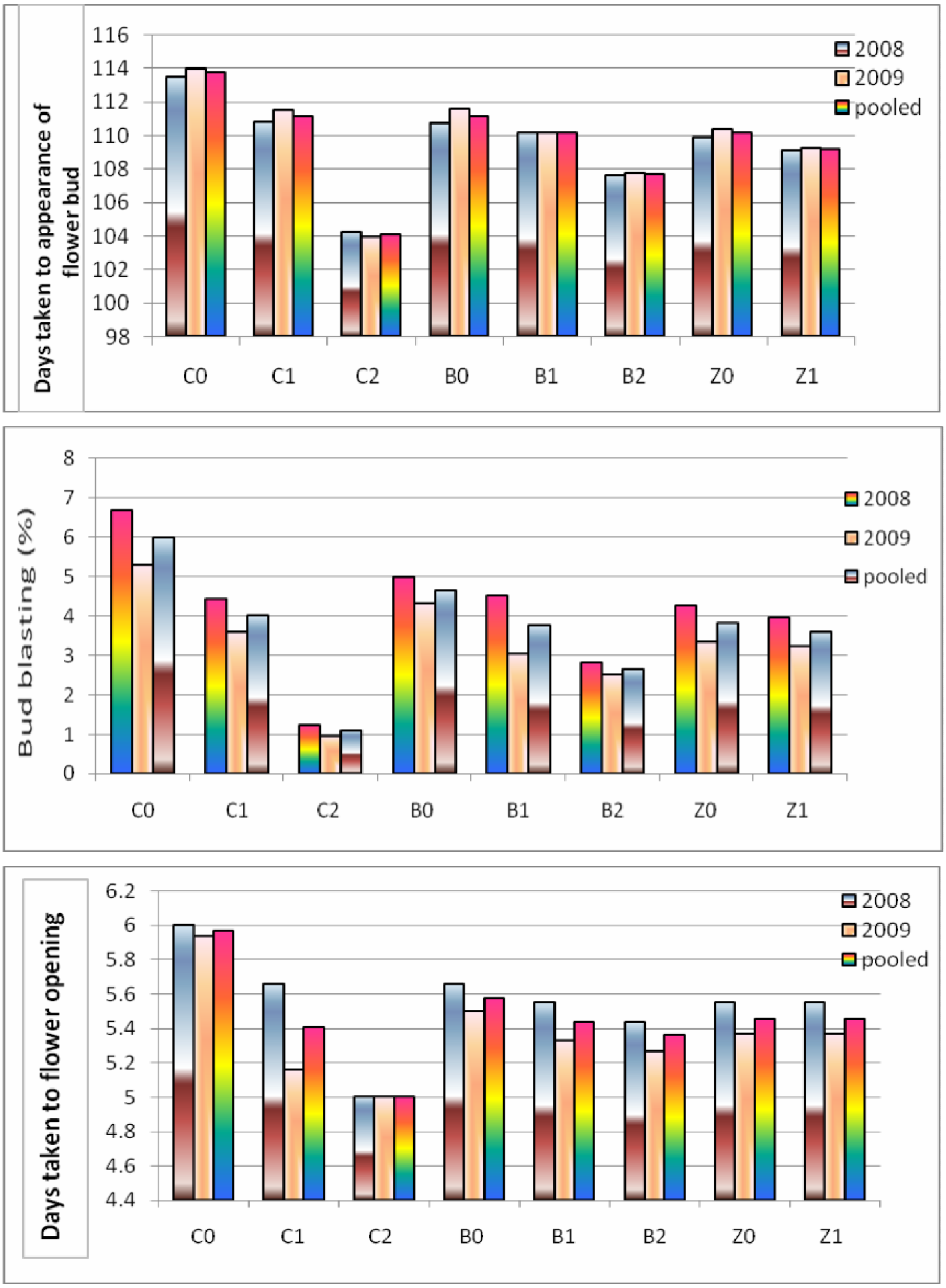
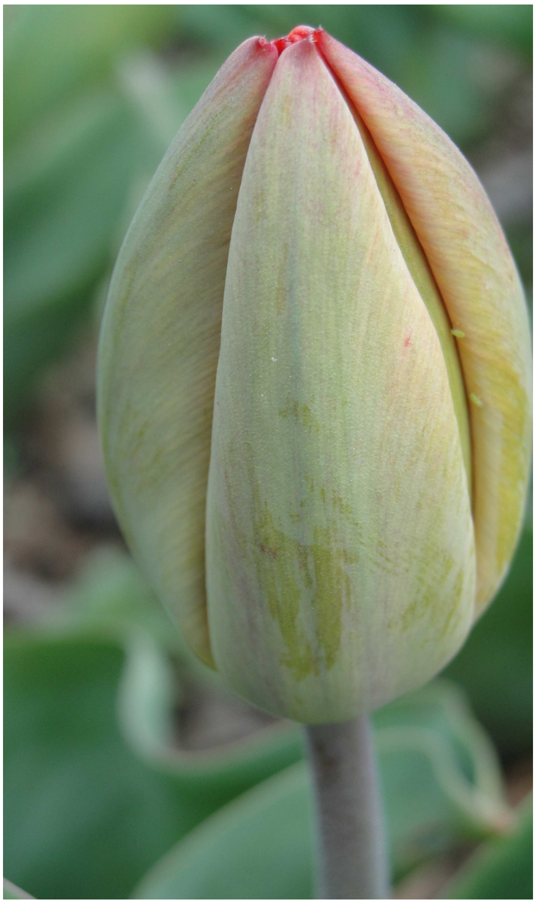
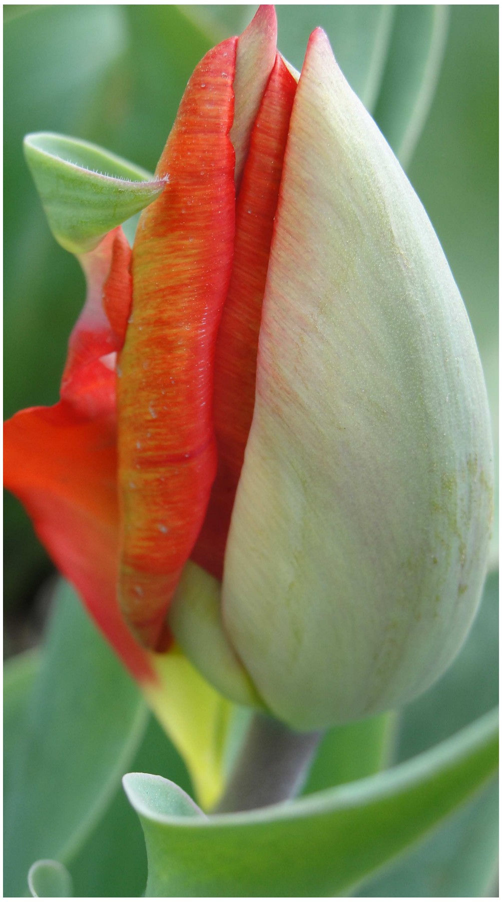
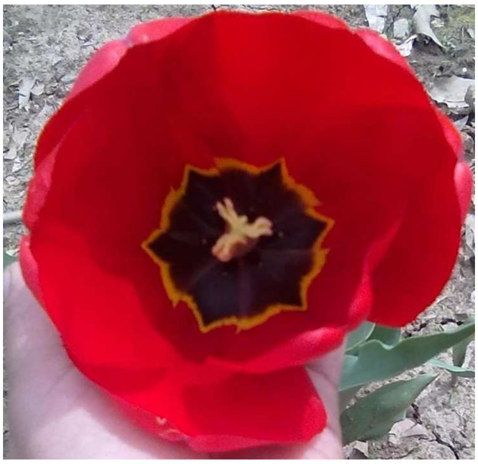


Fig. 5 : Effect of Ca, B and Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)



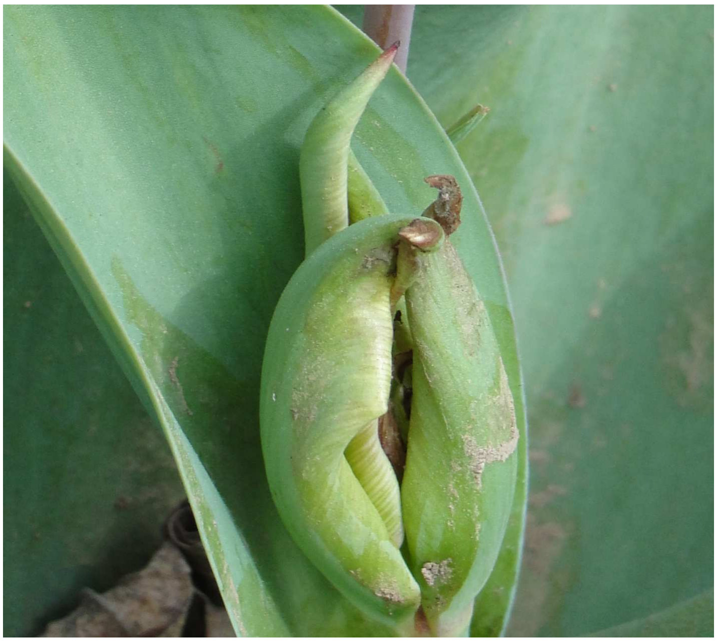


Colour breaking stage **Initiation of flower opening**



Flowering opening **A fully open tulip flower**

Plate-2 : Flowering stages of tulip



Bud blast

Boron deficiency

Horizontal cracking due to boron deficiency

Plate-3 : Physiological disorder occurring due to calcium and boron deficiencies

Further examination of the data indicated that the differences in days taken to flower opening due to various levels of boron were non-significant.

The differences recorded in days taken to flower opening in different levels of zinc was also statistically non-significant.

Interaction effects of two nutrients are presented in Table-4.2.2. The interaction between calcium and boron levels exhibited a significant variation for days taken to flower opening. Highest number of days taken to flower opening (6.00) was recorded in C_0B_0 treatment combination and the lowest (5.16 day) was recorded with C_2B_2 treatment combination.

The interactive influence between calcium and zinc levels on the days taken to flower opening was also significant. Lesser number of days (5.00) was recorded under C_2Z_1 treatment combinations whereas more number of days (6.00) was required for flower opening in C_0Z_0 treatment combination (Table-4.2.2).

Interaction of B and Zn was significant with regard to flower opening. Minimum number of days (5.33) was recorded under B_2Z_1 treatment combination and the highest number of days (5.61) was recorded under B_0Z_0 treatment combination.

An examination of the data (Table-4.2.3) indicated that the differences in days to flower opening due to various levels of calcium, boron and zinc interaction were highly significant. Minimum days (5.00) required for flower opening were noticed under $C_2B_2Z_1$ while maximum days (6.00) were recorded under the lowest level of calcium, boron and zinc (0.00 kg ha^{-1}).

4.2.5 Flower diameter (cm)

Different nutrients tested in present experiment depicted significant differences in the flower diameter (Table 4.2.4 and Fig. 6). Maximum flower diameter (8.76 cm) was recorded under calcium (10.00 kg ha^{-1}), whereas, lowest flower diameter (7.66 cm) was recorded in plants treated with zero level of calcium.

Perusal of mean values for flower diameter under different boron levels reflected that application of boron caused significant increase in flower diameter however, increase in application rate of boron from 0.5 to 1.00 kg ha^{-1} depicted significant variation in flower diameter. The highest flower diameter (8.40 cm) was observed under boron at 1.00 kg ha^{-1} (B_2) and the lowest flower diameter (8.05 cm) was observed under boron at 0.00 kg ha^{-1} (B_0). Although the application of zinc at 8.00 kg ha^{-1} (Z_1) recorded maximum flower diameter (8.26 cm) compared to minimum flower diameter (8.18 cm) with the application of zinc at 0.00 kg ha^{-1} (Z_0), yet the differences were statistically non-significant.

The interaction between calcium and boron showed a significant variation in flower diameter. The maximum flower diameter (8.95 cm) was recorded under C_2B_2 treatment combination followed by C_2B_1 (8.75 cm), C_2B_0 (8.59 cm) and C_1B_2 (8.40 cm), whereas, minimum (7.52 cm) was observed under C_0B_0 treatment combination (Table 4.2.5). Different combinations of calcium and zinc levels also caused significant variation in flower diameter. The best flower diameter was recorded under C_2Z_1, C_2Z_0 and C_1Z_1 treatment combinations in comparison to C_1Z_0, C_0Z_1 and C_0Z_0 treatment combinations. The interactive influence between boron and zinc levels on flower diameter was also significant. Maximum flower diameter (8.48 cm) was recorded under B_2Z_1 treatment combination whereas minimum flower diameter (8.05 cm) was observed under B_0Z_0 treatment combination.

The perusal of data from Table-4.2.6 revealed that the interactive influence of calcium, boron and zinc, highest (8.96 cm) and lowest (7.51 cm) flower diameters were observed for calcium 10.00, boron 1.00 and zinc 8.00 kg ha^{-1}, and calcium, boron and zinc with 0.00 kg ha^{-1}, respectively. The highest flower diameter was followed in descending order by $C_2B_2Z_0$ (8.93 cm), $C_2B_1Z_1$ (8.80 cm) and $C_2B_1Z_0$ (8.70 cm).

The interaction between $C_2B_2Z_0$, $C_2B_1Z_1$, $C_2B_1Z_0$, $C_2B_0Z_1$ were statistically at par with each other at 5 per cent level of significance.

4.2.6 Scape length (cm)

Data on scape length as influenced by different nutrient levels are summarised in Table- 4.2.4. and Fig. 6. Individual effects of calcium showed that largest scape length (21.69 cm) was recorded under calcium 10.00 kg ha^{-1} whileas, smallest scapes (19.25 cm) were observed under plots treated with zero level of calcium.

The application of boron had a significant impact on scape length. Longest scapes (21.09 cm) were produced when boron was supplied at 1.00 kg ha^{-1}. This was followed by the application of boron at 0.5 kg ha^{-1} which resulted in scape length of 20.31 cm as compared with shortest scape length (19.75 cm), recorded at 0.0 kg ha^{-1} of boron.

Scape length altered significantly due to different levels of zinc as well. Tulip plants receiving 8.00 kg zinc ha^{-1} showed maximum scape length (20.54 cm) where as smallest scapes (20.23 cm) were recorded under 0.00 kg zinc ha^{-1}.

Among the interactive influences of two factors showed a significant variation with regard to scape length (Table 4.2.5). The longest scapes (22.96 cm) were recorded under C_2B_2 while as the shortest scapes (18.57 cm) were observed under C_0B_0 treatment combination. Most of the interactions were however, statistically at par with each other.

The interaction between different levels of calcium and zinc also produced a significant variation in this character. Maximum scape length (21.93 cm) was recorded in C_2Z_1, whereas lowest scape length (19.07 cm) was recorded in C_0Z_0 treatment combination.

Perusal of means values for scape length and the interaction between boron and zinc levels proved to be beneficial in improving the scale length. The treatment combination B_2Z_1 recorded highest scape length of 21.19 cm whereas, the smallest scape length of 19.67 cm was recorded when 0.00 kg ha^{-1} boron and zinc was applied.

Various treatment combinations of calcium, boron and zinc resulted in significant variations in scape length (Table 4.2.6). It is vivid from the data that significantly highest (25.88 cm) scape length was recorded with $C_2B_2Z_1$ followed by $C_2B_2Z_0$ (25.60 cm) and $C_2B_1Z_1$ (25.17cm). The lowest (21.28cm) scape length was recorded under $C_0B_0Z_0$ treatment combination. However, the interactions between treatment combinations $C_2B_2Z_0$ and $C_2B_1Z_1$ were statistically at par at 5 per cent level of significance.

4.2.7 Scape thickness (mm)

Data pertaining to scape thickness influenced by different nutrients are presented in Table 4.2.4. Data exhibited a significant variation for calcium application. Increasing levels of Ca caused an increased scape thickness and maximum (6.69 mm) was recorded with Ca at 10.00 kg ha^{-1} whileas, the lowest value (5.81mm) was recorded under control.

Boron levels caused insignificant variation in terms of scape thickness. Boron at 1.00 kg ha^{-1} depicted maximum scape thickness 6.38 mm while minimum scape thickness (6.11 mm) was record under 0.00 kg boron ha^{-1}. Zinc had insignificant influence on the scape thickness as well.

Combination of two factors showed a significant variation with regard to scape thickness (Table 4.2.5). The scape thickness was maximum under C_2B_2 (6.79 mm) followed by C_2B_1 (6.75 mm) and C_2B_0 (6.53 mm) and minimum scape thickness 5.66 mm was recorded under C_0B_0.

Calcium and zinc interaction effect revealed that different calcium and zinc levels caused significant variation in scape thickness. Calcium at 10.00 kg ha^{-1} and zinc at 8.00 kg ha^{-1} recorded the maximum scape thickness (6.75 mm) followed by C_2Z_0 (6.63 mm) while as minimum scape thickness (5.77 mm) was recorded under C_0Z_0. The interaction between boron and zinc affect the scape thickness significantly, where maximum scape thickness (6.41 mm) was record with B_2Z_1 treatment combination and minimum (6.11 mm) under B_0Z_0 treatment combination.

The interaction between Ca × B × Zn significantly affects the stem thickness (Table 4.2.6). Maximum stem thickness of 6.84 mm was recorded under the treatment combination of $C_2B_2Z_1$ followed by $C_2B_2Z_0$ (6.81 mm) and $C_2B_1Z_1$ (6.77 mm) and minimum 5.54 mm scape thickness attained under $C_0B_0Z_0$ treatment combination.

4.2.8 Stem topple (%)

The three levels tried in this study, revealed significant variations in stem topple (Table 4.2.4 and Fig. 6). Increasing levels of Ca significantly decreased the stem topple per cent and there was no stem topple in Ca 10.00 kg ha^{-1} as compared to 4.65% stem topple under control.

Perusal of data revealed that application of boron at 1.00 kg ha^{-1} resulted in minimum stem topple (1.25%) while boron applied at 0.00 kg ha^{-1} resulted in maximum stem topple (2.40%). The table indicates that the application of zinc also influenced the stem topple significantly with lowest stem topple (1.63 %) under 8.00 kg ha^{-1}, whereas, the highest stem topple recorded under control was 1.92 per cent.

Interaction data of two factors (Table 4.2.5) also exhibited a significant variation in terms of stem topple per cent. Interaction of Ca and B had a significant influence on this particular parameter. The interaction between treatment combinations C_2B_2, C_2B_1, C_2B_0 and C_1B_2 resulted in no stem topple against the maximum stem topple of 5.33% was recorded under C_0B_0 treatment combination.

The interaction between Ca x Zn levels influenced the stem topple per cent significantly. Minimum stem topple i.e. 0.00 % was recorded under C_2Z_1 treatment combination and maximum 4.80 % was recorded under C_0Z_0 with 0.00 kg ha^{-1} of calcium and zinc each.

Data further revealed significantly minimum stem topple (1.25%) under the influence of boron 1.00 kg ha^{-1} and zinc 8.00 kg ha^{-1} in opposed to 2.66% stem topple recorded under boron and zinc at 0.00 kg ha^{-1}.

A favourable interaction of different nutrient levels was also observed in the present study (Table 4.2.6). Highest stem topple (5.33%) was recorded with lowest level of calcium (0.00 kg), boron (0.00 kg) and zinc (0.00 kg ha^{-1}) whereas no stem topple was recorded under treatment combination $C_2B_2Z_1$. However, the interactions between treatment combinations $C_2B_2Z_0$, $C_2B_1Z_1$, $C_2B_1Z_0$, $C_2B_0Z_1$, $C_2B_0Z_0$, $C_1B_2Z_1$, $C_1B_2Z_0$ and $C_1B_1Z_1$ were statistically at par with zero stem topple per cent.

4.2.9 Field life (day)

The field life is a function of different parameters and is influenced by calcium, boron and zinc levels are presented in Table-4.2.4.

The field life as influenced by different calcium levels revealed that less number of days (142.59) was significantly taken in the field under untreated control compared to 5.00 and 10.00 kg ha^{-1} of calcium application where 147.77 and 151.50 days were recorded, respectively.

An examination of data revealed that application of boron increased the field life significantly. Boron applied at 1.00 kg ha^{-1} recorded the maximum number of days (148.31) while B at 0.00 kg ha^{-1} produced the minimum number of days (146.16).

Similarly with the application of zinc the field life tended to increase, maximum days (147.61) was observed with 8.00 kg ha^{-1} Zn and the minimum (146.96 day) under Zn applied at 0.00 kg ha^{-1}.

Under the interactive influence of two factors (Table-4.2.5), maximum field life (152.83 day) was recorded in calcium (10.00 kg ha^{-1}) with highest level of boron (1.00 kg ha^{-1}), whereas the minimum field life (141.66 day) was recorded for 0.00 kg ha^{-1} of calcium and boron each.

Table 4.2.4: Effect of Ca, B and Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Flower diameter (cm)			Scape length (cm)			Scape thickness (mm)			Stem topple (%)			Field life (day)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Calcium (kg ha^{-1})															
C_0 (0)	7.61	7.72	7.66	19.03	19.48	19.25	5.71	5.91	5.81	5.19	4.11	4.65	141.73	143.44	142.59
C_1 (5.00)	8.11	8.36	8.23	19.93	20.48	20.21	6.17	6.37	6.27	0.97	0.41	0.69	147.17	148.38	147.77
C_2 (10.00)	8.68	8.84	8.76	21.35	22.04	21.69	6.64	6.74	6.69	0.00	0.00	0.00	150.88	152.13	151.50
C.D$_{(P\leq0.05)}$	**0.11**	**0.14**	**0.11**	**0.35**	**0.28**	**0.27**	**0.36**	**0.36**	**0.36**	**0.29**	**0.27**	**0.20**	**0.63**	**0.58**	**0.12**
Boron (kg ha^{-1})															
B_0 (0)	7.97	8.13	8.05	19.52	19.99	19.75	6.03	6.20	6.11	2.63	2.16	2.40	145.53	146.79	146.16
B_1 (0.5)	8.14	8.27	8.21	20.01	20.61	20.31	6.20	6.36	6.28	1.86	1.52	1.69	146.77	148.01	147.39
B_2 (1.00)	8.30	8.51	8.40	20.79	21.4	21.09	6.29	6.46	6.38	1.66	0.83	1.25	147.48	149.14	148.31
C.D$_{(P\leq0.05)}$	**0.11**	**0.14**	**0.11**	**0.35**	**0.28**	**0.27**	**0.07**	**0.07**	**0.07**	**0.29**	**0.27**	**0.20**	**0.63**	**0.58**	**0.12**
Zinc (kg ha^{-1})															
Z_0 (0)	8.10	8.25	8.18	19.95	20.51	20.23	6.16	6.33	6.24	2.12	1.72	1.92	146.33	147.59	146.96
Z_1 (8.00)	8.17	8.35	8.26	20.26	20.82	20.54	6.19	6.35	6.27	1.98	1.29	1.63	146.86	148.37	147.61
C.D$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.28**	**0.23**	**0.22**	**0.06**	**0.06**	**0.06**	**NS**	**0.22**	**0.16**	**NS**	**0.47**	**0.42**

NS = Non-significant

Table 4.2.5 : Interaction effect of Ca x B, Ca x Zn and B x Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Flower diameter (cm)			Scape length (cm)			Scape thickness (mm)			Stem topple (%)			Field life (day)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Ca x B (kg ha^{-1})															
C_0B_0	7.48	7.56	7.52	18.39	18.76	18.57	5.56	5.76	5.66	5.41	5.25	5.33	140.93	142.38	141.66
$C_0 B_1$	7.60	7.63	7.61	19.09	19.54	19.31	5.69	5.89	5.79	5.16	4.58	4.87	142.10	143.42	143.31
$C_0 B_2$	7.76	7.96	7.86	19.61	20.15	19.88	5.87	6.07	5.97	5.00	2.50	3.75	142.17	144.52	142.79
C_1B_0	7.93	8.15	8.04	19.76	20.26	20.01	6.06	6.26	6.16	2.50	1.25	1.87	146.20	147.28	146.74
$C_1 B_1$	8.15	8.38	8.26	19.87	20.47	20.17	6.20	6.40	6.30	0.41	0.00	0.20	147.17	148.40	147.78
$C_1 B_2$	8.26	8.55	8.40	20.17	20.71	20.44	6.27	6.47	6.37	0.00	0.00	0.00	148.13	149.45	148.79
$C_2 B_0$	8.50	8.68	8.59	20.41	20.96	20.68	6.48	6.58	6.53	0.00	0.00	0.00	149.45	150.70	150.07
$C_2 B_1$	8.68	8.81	8.75	21.06	21.83	21.45	6.70	6.80	6.75	0.00	0.00	0.00	150.98	152.22	151.60
$C_2 B_2$	8.86	9.03	8.95	22.57	23.34	22.96	6.74	6.84	6.79	0.00	0.00	0.00	152.20	153.47	152.83
$CD_{(P\leq0.05)}$	**0.20**	**0.24**	**0.20**	**0.60**	**0.49**	**0.47**	**0.07**	**0.07**	**0.07**	**0.47**	**0.51**	**0.35**	**1.09**	**1.01**	**0.95**
Ca x Zn (kg ha^{-1})															
C_0Z_0	7.58	7.64	7.61	18.85	19.29	19.07	5.67	5.87	5.77	5.27	4.33	4.80	141.53	142.91	142.22
C_0Z_1	7.64	7.80	7.72	19.21	19.67	19.44	5.74	5.94	5.84	5.11	3.88	4.50	141.93	143.97	142.95
C_1Z_0	8.07	8.31	8.19	19.88	20.43	20.16	6.16	6.36	6.26	1.11	0.83	0.97	146.96	148.11	147.53
C_1Z_1	8.15	8.41	8.28	19.99	20.52	20.26	6.19	6.39	6.29	0.83	0.00	0.41	147.38	148.64	148.01
C_2Z_0	8.65	8.82	8.73	21.11	21.8	21.46	6.58	6.68	6.63	0.00	0.00	0.00	150.49	151.76	151.12
C_2Z_1	8.71	8.86	8.78	21.58	22.28	21.93	6.70	6.80	6.75	0.00	0.00	0.00	151.27	152.50	151.88
$CD_{(P\leq0.05)}$	**0.16**	**0.20**	**0.16**	**0.49**	**0.40**	**0.38**	**0.10**	**0.10**	**0.10**	**0.38**	**0.42**	**0.28**	**0.89**	**0.83**	**0.77**
$B_0 Z_0$	7.95	8.15	8.05	19.44	19.91	19.67	6.02	6.19	6.11	2.66	2.66	2.66	145.34	146.39	145.87
$B_0 Z_1$	7.98	8.11	8.05	19.6	20.07	19.84	6.03	6.20	6.12	2.61	1.66	2.13	145.71	147.19	146.45
$B_1 Z_0$	8.12	8.22	8.17	19.72	20.32	20.02	6.19	6.36	6.27	2.05	1.66	1.86	146.48	147.71	147.09
$B_1 Z_1$	8.16	8.33	8.25	20.3	20.91	20.6	6.21	6.37	6.29	1.66	1.38	1.52	147.07	148.31	147.69
$B_2 Z_0$	8.21	8.44	8.32	20.69	21.3	20.99	6.26	6.43	6.35	1.66	0.83	1.25	147.16	148.68	147.92
$B_2 Z_1$	8.38	8.58	8.48	20.88	21.49	21.19	6.33	6.49	6.41	1.66	0.83	1.25	147.80	149.61	148.71
$CD_{(P\leq0.05)}$	**0.16**	**0.20**	**0.16**	**0.49**	**0.40**	**0.38**	**0.10**	**0.10**	**0.10**	**0.38**	**0.42**	**0.28**	**0.89**	**0.83**	**0.77**

Table 4.2.6: Combined effect of Ca, B and Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment combination	Flower diameter (cm)			Scape length (cm)			Scape thickness (cm)			Stem topple (%)			Field life (day)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
C_0 B_0 Z_0	7.43	7.60	7.51	20.97	21.59	21.28	5.44	5.64	5.54	5.33	5.33	5.33	140.80	142.77	141.78
C_0 B_0 Z_1	7.53	7.53	7.53	21.71	22.33	22.02	5.67	5.87	5.77	5.50	5.16	5.33	141.07	142.00	141.53
C_0 B_1 Z_0	7.53	7.70	7.61	22.02	22.64	22.33	5.71	5.91	5.81	5.33	5.00	5.16	141.73	142.97	142.35
C_0 B_1 Z_1	7.56	7.83	7.70	22.59	23.21	22.9	5.68	5.88	5.78	5.00	3.33	4.16	141.80	143.77	142.78
C_0 B_2 Z_0	7.66	7.56	7.61	22.72	23.34	23.03	5.84	6.04	5.94	5.00	3.33	4.16	142.40	145.27	143.83
C_0 B_2 Z_1	7.93	8.13	8.03	22.97	23.59	23.28	5.90	6.10	6.00	5.00	2.50	3.75	142.60	143.87	143.23
C_1 B_0 Z_0	7.93	8.16	8.05	23.09	23.71	23.40	6.02	6.22	6.12	2.50	2.50	2.50	146.00	146.90	146.45
C_1 B_0 Z_1	7.96	8.10	8.03	23.24	23.9	23.57	6.10	6.30	6.20	2.50	0.00	1.25	146.40	147.67	147.03
C_1 B_1 Z_0	8.10	8.30	8.20	23.28	23.94	23.61	6.24	6.44	6.34	0.83	0.00	0.41	146.87	148.10	147.48
C_1 B_1 Z_1	8.20	8.46	8.33	23.28	23.94	23.61	6.16	6.36	6.26	0.00	0.00	0.00	147.47	148.70	148.08
C_1B_2 Z_0	8.20	8.50	8.35	23.30	23.96	23.63	6.22	6.42	6.32	0.00	0.00	0.00	148.00	149.33	148.67
C_1 B_2 Z_1	8.33	8.60	8.46	23.52	24.28	23.9	6.32	6.52	6.42	0.00	0.00	0.00	148.27	149.57	148.92
C_2 B_0 Z_0	8.50	8.66	8.58	23.58	24.33	23.95	6.42	6.52	6.47	0.00	0.00	0.00	148.97	150.27	149.62
C_2B_0 Z_1	8.50	8.70	8.60	24.03	24.81	24.42	6.54	6.64	6.59	0.00	0.00	0.00	149.93	151.13	150.53
C_2 B_1 Z_0	8.60	8.80	8.70	24.14	24.92	24.53	6.62	6.72	6.67	0.00	0.00	0.00	150.83	152.07	151.45
C_2 B_1 Z_1	8.76	8.83	8.80	24.78	25.56	25.17	6.72	6.82	6.77	0.00	0.00	0.00	151.13	152.37	151.75
C_2 B_2 Z_0	8.86	9.00	8.93	25.22	25.99	25.60	6.76	6.86	6.81	0.00	0.00	0.00	151.67	152.93	152.30
C_2 B_2 Z_1	8.86	9.06	8.96	25.50	26.27	25.88	6.79	6.89	6.84	0.00	0.00	0.00	152.73	154.00	153.37
C.D$_{(P\leq0.05)}$	**0.28**	**0.35**	**0.28**	**0.35**	**0.57**	**0.57**	**0.18**	**0.18**	**0.18**	**0.73**	**0.67**	**0.49**	**1.54**	**1.43**	**1.34**

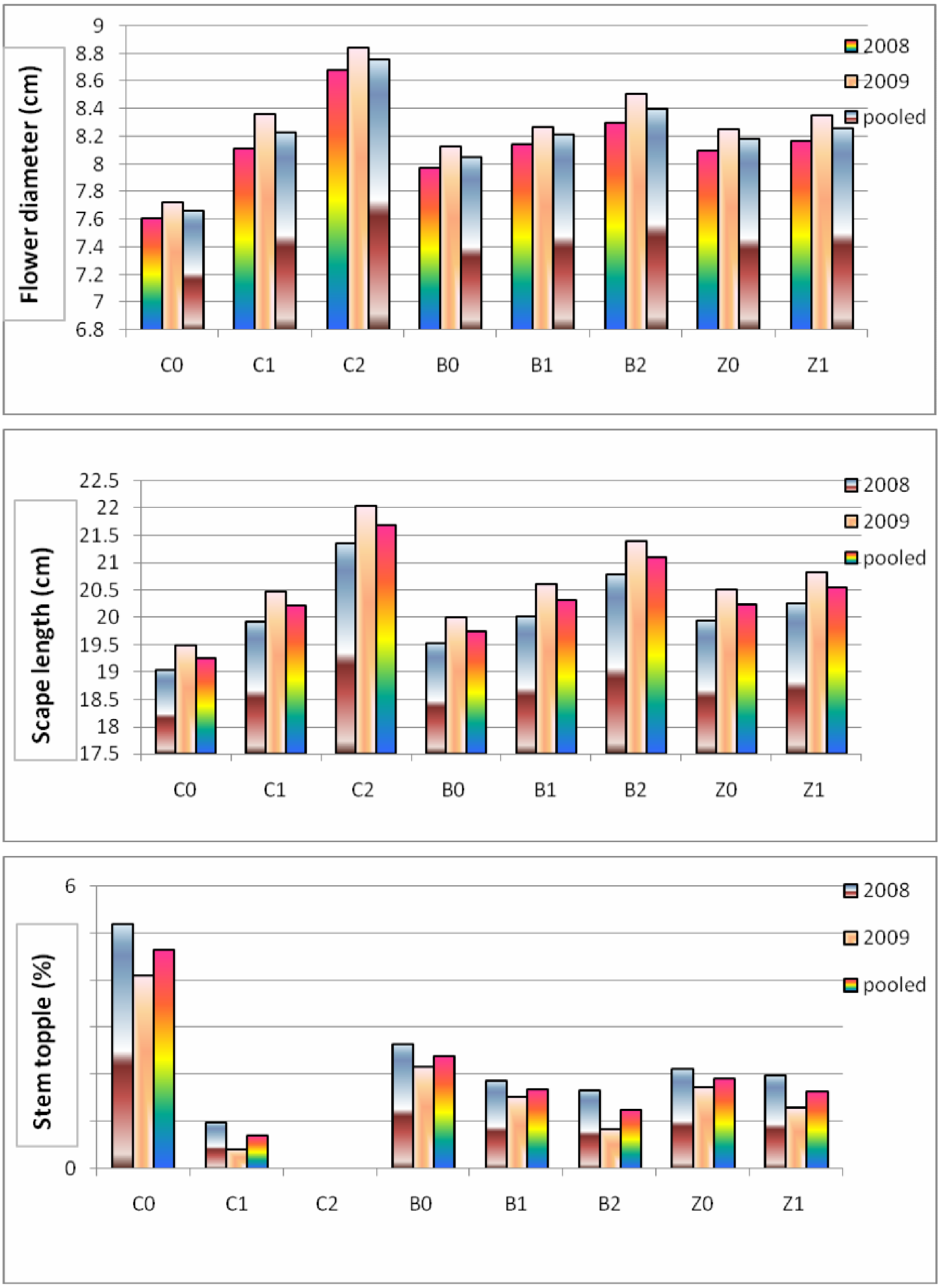


Fig. 6 : Effect of Ca, B and Zn on floral characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

The interaction between Ca and Zn levels caused significant impact on field life. Maximum number of days (151.88) in terms of field life was recorded under Ca (10.00 kg ha^{-1}) with application of boron (1.00 kg ha^{-1}) and minimum days (142.22) was recorded in Ca (0.00 kg ha^{-1}) with B (0.00 kg ha^{-1}).

Perusal of the data presented in Table-4.2.5 revealed that the interaction between B and Zn caused a significant variation on field life. Maximum field life (148.71) was recorded under B (1.00 kg ha^{-1}) in combination with Zn (8.00 kg ha^{-1}) and minimum field life (145.87) was observed under B (0.00 kg ha^{-1}) and Zn (0.00 kg ha^{-1}).

Perusal of data (Table-4.2.6) on field life revealed that interaction between calcium, boron and zinc had a significant effect during both the years of investigation. Maximum field life (153.37 day) was recorded with highest level of Ca (10.00 kg ha^{-1}), B (1.00 kg ha^{-1}) and Zn (8.00 kg ha^{-1}) followed by $C_2B_2Z_0$ (152.30 day), $C_2B_1Z_1$ (151.75 day) and $C_2B_1Z_0$ (151.45 day), whereas, the minimum field life (141.78 day) was recorded with minimum level of Ca (0.00 kg ha^{-1}), B (0.00 kg ha^{-1}) and Zn (0.00 kg ha^{-1}).

4.3 Bulb characters

4.3.1 Number of bulbs lifted per m^2

The data on number of bulbs lifted per m^2 in tulips as influenced by different levels of calcium, boron and zinc are presented in Table-4.3.1 and graphically illustrated in Fig. 7.

The number of bulbs m^{-2} recorded under different levels of calcium showed significant variation. Increasing the level of calcium from 5.00 to 10.00 kg ha^{-1} increased the number of bulbs m^{-2}, the highest number of bulbs (57.27) was lifted m^{-2} under high dose of calcium 10.00 kg ha^{-1}and lowest number of bulbs (48.00) was lifted under low dose of calcium 0.00 kg ha^{-1}.

The application of boron also proved to be beneficial in enhancing bulb production. The highest number of bulbs m^{-2} (54.02) was recorded under 1.00 kg boron (B_2) followed by 52.25 with 0.50 kg boron ha^{-1} (B_1) and lowest number of bulbs m^{-2} (50.80) was recorded under 0.00 kg boron application (Table 4.3.1).

Plots treated with zinc at 8.00 kg ha^{-1} produced the maximum number of bulbs m^{-2} (53.38) whereas, minimum 51.33 number of bulbs per metre square was recorded under zinc at 0.00 kg ha^{-1}.

Data on two way interaction (Table 4.3.2) revealed that the interactive influence of calcium and boron also had a significant impact on number of bulbs m^{-2}. Calcium at 10.00 kg ha^{-1} along with highest level of boron (1.00 kg ha^{-1}) recorded highest number of bulbs (59.75) m^{-2}, whereas minimum number of bulbs (46.41) m^{-2} was observed with calcium and boron at 0.00 kg ha^{-1} (C_0B_0).

The interaction between calcium and zinc levels exhibited a significant variation with regard to number of bulbs lifted per meter square. The treatment combination of C_2Z_1 produced the highest number of bulbs (59.61) per meter square which was significantly more than that of C_0Z_0 treatment combination (47.66) which produced the lowest number of bulbs per meter square.

Under the interactive influence between boron and zinc the maximum bulbs m^{-2} was found to be maximum (55.00) with B_2Z_1 and minimum number (49.94) with B_0Z_0 treatment combination.

The interaction between calcium, boron and zinc showed significant difference in the production of number of bulbs m^{-2} (Table 4.3.3). The treatment combination of $C_2B_2Z_1$ produced the highest number of bulbs m^{-2} (61.66) followed by $C_2B_2Z_0$ (60.33), $C_2B_1Z_1$ (57.83) and $C_2B_1Z_0$ (56.83) whereas, the lowest number of bulbs per square meter was recorded with $C_0B_0Z_0$ treatment combination (46.16).

4.3.2 Weight of bulbs lifted m^2 (g)

Bulb weight differed in different nutrient levels tested in the present study (Table 4.3.1 and Fig. 7). Calcium (10.00 kg ha^{-1}) produced heaviest bulbs (783.41 g m^{-2}) while calcium at 0.00 kg ha^{-1} recorded lightest bulbs (723.51 g m^{-2}).

Application of boron also influenced the bulb weight and maximum (765.99 g m^{-2}) was recorded with an application of 1.00 kg ha^{-1} followed by 755.72 g and 743.11 g with the application of 0.50 and 0.00 kg ha^{-1} of boron respectively. Application of zinc also resulted in significant improvement in the weight of bulbs. The highest weight of bulbs (757.39 g m^{-2}) was obtained under 8.00 kg ha^{-1} and lowest weight of bulbs (752.50 g m^{-2}) was obtained under 0.00 kg ha^{-1} of zinc (Z_0).

Data pertaining to the interaction between two nutrients are presented in Table-4.3.2. The interaction between different calcium and boron levels manifested its effect on the weight of bulbs. Maximum bulb weight (788.47 g m^{-2}) was noticed under C_2B_2 combination and minimum (705.65 g m^{-2}) under C_0B_0 treatment combination.

The interactions between calcium and zinc showed that maximum weight of bulbs was recorded under C_2Z_1 (784.84 g m^{-2}) and minimum (720.94 g m^{-2}) was recorded with calcium and zinc at 0.00 kg ha^{-1}.

Under the interactive influence of boron and zinc, weight of bulbs per m^{-2} was found to be maximum (768.75 g) with B_2Z_1 combination and minimum (742.10 g) with B_0Z_0 treatment combination.

Three way interactions of the data (Table-4.3.3) indicate that the interaction between calcium, boron and zinc levels exhibited a significant influence on the weight of bulbs m^{-2}. The treatment combination of $C_2B_2Z_1$ produced the highest weight of bulbs (790.00 g m^{-2}) which was significantly more than that of $C_0B_0Z_0$ treatment combination (704.63 g m^{-2}). The highest bulb weight was followed by $C_2B_2Z_0$ and $C_2B_1Z_1$ and were statistically at par with each other.

4.3.3 Weight of bulblets (g m^{-2})

Bulblets weight of tulip under the influence of different nutrient treatments are presented in Table 4.3.1 and Fig. 7.

Perusal of data indicate that bulblets attained the maximum weight (387.88 g m^{-2}) in calcium at 10.00 kg ha^{-1}, whereas the minimum weight (298.42 g m^{-2}) was recorded at 0.00 kg Ca ha^{-1}.

Application of boron from 0.00 to 1.00 kg ha^{-1} caused a significant improvement in bulblet weight. Highest weight (356.94 g) was recorded with 1.00 kg ha^{-1} of boron, whereas, lowest bulblets weight (322.09 g m^{-2}) was recorded with 0.00 kg ha^{-1}. Similarly, application of zinc 8.00 kg ha^{-1} also registered significantly bulblet weight (344.84 g) as compared with untreated control (334.73 g m^{-2}).

Data on two way interaction effect (Table 4.3.2) revealed that different calcium and boron levels caused significant variation in bulblets weight. Tulips supplied with calcium at 10.00 kg ha^{-1} and boron at 1.00 kg ha^{-1} recorded the maximum bulblet weight (411.38 g), followed by C_2B_1 (388.47 g), C_2B_0 (363.77 g) and C_1B_2 (347.88 g m^{-2}), whereas, calcium 0.00 kg ha^{-1} applied with 0.00 kg ha^{-1} boron recorded the minimum bulblet weight (282.05 g m^{-2}).

The interaction between calcium and zinc also recorded significant impact on bulblets weight. Calcium at 10.00 kg ha^{-1} applied with zinc 8.00 kg ha^{-1} recorded significantly highest bulblet weight (394.79 g), whereas, calcium 0.00 kg ha^{-1} applied with zinc 0.00 kg ha^{-1} recorded the lowest bulblets weight (293.37g m^{-2}).

Boron in combination with zinc resulted in maximum bulblet weight (360.76 g) in a treatment combination of B_2Z_1 which was significantly superior to B_0Z_0 treatment combination produced the minimum bulblet weight of 315.70 g per square meter.

Under the three way interactive influence of calcium, boron and zinc (Table 4.3.3), weight of bulblets per m^{-2} was recorded maximum (417.33 g) with $C_2B_2Z_1$ treatment combination followed by $C_2B_2Z_0$ (405.43 g), $C_2B_1Z_1$ (396.57 g) and $C_2B_1Z_0$ (380.38 g m^{-2}) whereas minimum (271.80 g) with $C_0B_0Z_0$ treatment combination.

4.3.4 Bulb production ratio

Data related to bulb production ratio as influenced by different nutrients are summarised in Table-4.3.1 and Fig. 7. There was significant increasing trend in the bulb production ratio with the increase in the calcium level. Highest bulb production ratio (1.43) was recorded under C_2 with calcium at 10.00 kg ha^{-1}, which was followed by 1.29 recorded under C_1, however, significantly lowest bulb production ratio (1.20) was recorded when calcium was not applied.

The application of boron also proved to be beneficial. The highest ratio of bulbs (1.35) was recorded under 1.00 kg boron ha^{-1} and lowest ratio of bulbs (1.27) was recorded under 0.00 kg of boron ha^{-1}.

Data pertaining to bulb production ratio in tulip as influenced by the application of zinc revealed a widest ratio of 1.33 in zinc at 8.00 kg ha^{-1} whereas, narrowest ratio of 1.28 was observed in zinc at 0.00 kg ha^{-1}.

The interaction effect data (Table 4.3.2) clearly indicated that with the increase in rate of application of calcium and boron combindly there occurred a corresponding increase in bulb production ratio. The ratio was highest (1.49) under C_2B_2 followed by 1.42 under C_2B_1 and only 1.16 under C_0B_0.

A similar trend was observed with regard to the influence of calcium and zinc interaction. Data indicate significantly higher bulb production ratio (1.49) under calcium 10.00 kg ha^{-1} and zinc 8.00 kg ha^{-1}, compared with lowest ratio (1.19) under 0.00 kg ha^{-1} of calcium and zinc, respectively.

Perusal of interaction effect data revealed that interaction between different levels of boron and zinc caused a significant increase in bulb production ratio. The maximum ratio (1.37) was observed with boron 1.00 kg ha^{-1} and zinc 8.00 kg ha^{-1} whereas, minimum ratio (1.24) was recorded under B_0Z_0 with zero kg ha^{-1} of boron and zinc.

The interactive influence of calcium, boron and zinc levels were also significant (Table 4.3.3). Bulbs with a maximum production ratio of 1.54 was noticed in a treatment combination of $C_2B_2Z_1$, while $C_0B_0Z_0$ resulted in

Table 4.3.1: Effect of Ca, B and Zn on bulb characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Number of bulbs lifted m^{-2}			Weight of bulbs lifted m^{-2} (g)			Weight of bulb lets lifted m^{-2} (g)			Bulb production ratio		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Calcium (kg ha^{-1})												
C_0 (0)	45.50	50.50	48.00	722.26	724.76	723.51	274.64	322.20	298.42	1.13	1.26	1.20
C_1 (5.00)	49.00	54.61	51.80	755.69	760.13	757.91	310.54	355.57	333.05	1.25	1.36	1.29
C_2 (10.00)	54.16	60.38	57.27	780.86	785.96	783.41	362.98	412.77	387.88	1.35	1.50	1.43
C.D$_{(P\leq0.05)}$	**0.84**	**0.54**	**0.50**	**2.19**	**2.24**	**2.21**	**7.33**	**5.92**	**5.10**	**0.02**	**0.01**	**0.01**
Boron (kg ha^{-1})												
B_0 (0)	48.33	53.27	50.80	741.25	744.98	743.11	299.37	344.81	322.09	1.20	1.33	1.27
B_1 (0.5)	49.22	55.27	52.25	753.76	757.69	755.72	317.45	363.20	340.32	1.23	1.38	1.30
B_2 (1.00)	51.11	56.94	54.02	763.79	768.19	765.99	331.34	382.53	356.94	1.27	1.42	1.35
C.D$_{(P\leq0.05)}$	**0.84**	**0.54**	**0.50**	**2.19**	**2.24**	**2.21**	**7.33**	**5.92**	**5.10**	**0.02**	**0.01**	**0.01**
Zinc (kg ha^{-1})												
Z_0 (0)	48.59	54.07	51.33	750.49	754.51	752.50	310.89	358.57	334.73	1.21	1.35	1.28
Z_1 (8.00)	50.51	56.25	53.38	755.38	759.39	757.39	321.23	368.46	344.84	1.26	1.40	1.33
C.D$_{(P\leq0.05)}$	**0.68**	**0.44**	**0.41**	**1.79**	**1.83**	**1.80**	**5.99**	**4.83**	**5.10**	**0.01**	**0.01**	**0.009**

Table 4.3.2 : Interaction effect of Ca x B, Ca x Zn and B x Zn on bulb characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Number of bulbs lifted m^{-2}			Weight of bulbs lifted m^{-2} (g)			Weight of bulb lets lifted m^{-2} (g)			Bulb production ratio		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Ca x B (kg ha^{-1})												
C_0B_0	44.00	48.83	46.41	704.77	706.53	705.65	259.92	304.18	282.05	1.10	1.22	1.16
$C_0 B_1$	45.50	50.50	48.00	727.70	730.33	729.02	278.13	325.22	301.67	1.13	1.26	1.20
$C_0 B_2$	47.00	52.16	49.58	734.30	737.42	735.86	285.88	337.20	311.54	1.17	1.30	1.23
C_1B_0	48.00	54.00	51.00	742.95	747.33	745.14	296.68	344.22	320.45	1.20	1.35	1.27
$C_1 B_1$	48.83	54.50	51.66	752.93	756.95	754.94	309.42	352.23	330.83	1.22	1.36	1.29
$C_1 B_2$	50.16	55.33	52.75	771.18	776.12	773.65	325.52	370.25	347.88	1.25	1.38	1.31
$C_2 B_0$	53.00	57.00	55.00	776.03	781.07	778.55	341.52	386.03	363.77	1.32	1.42	1.37
$C_2 B_1$	53.33	60.83	57.08	780.65	785.78	783.22	364.80	412.15	388.47	1.33	1.52	1.42
$C_2 B_2$	56.16	63.33	59.75	785.90	791.03	788.47	382.63	440.13	411.38	1.40	1.58	1.49
$CD_{(P\leq0.05)}$	**1.45**	**0.94**	**0.87**	**3.80**	**6.05**	**3.83**	**12.71**	**10.26**	**10.82**	**0.01**	**0.02**	**0.02**
Ca x Zn (kg ha^{-1})												
C_0Z_0	45.22	50.11	47.66	719.76	722.12	720.94	268.53	318.21	293.37	1.13	1.25	1.19
C_0Z_1	45.77	50.88	48.33	724.76	727.40	726.08	280.76	326.19	303.47	1.14	1.27	1.20
C_1Z_0	48.33	54.44	51.38	752.28	756.90	754.59	307.09	352.60	329.84	1.20	1.36	1.28
C_1Z_1	49.66	54.77	52.22	759.10	763.37	761.23	313.99	358.53	336.26	1.24	1.36	1.30
C_2Z_0	52.22	57.66	54.94	779.44	784.51	781.98	357.03	404.89	380.96	1.30	1.44	1.37
C_2Z_1	56.11	63.11	59.61	782.28	787.41	784.84	368.93	420.66	394.79	1.40	1.57	1.49
$CD_{(P\leq0.05)}$	**1.19**	**0.76**	**0.71**	**3.10**	**3.17**	**3.12**	**10.37**	**8.38**	**8.83**	**0.02**	**0.01**	**0.01**
B x Zn (kg ha^{-1})												
$B_0 Z_0$	47.33	52.55	49.94	740.19	744.01	742.10	292.14	339.26	315.70	1.18	1.31	1.24
$B_0 Z_1$	48.22	53.77	51.00	742.31	745.94	744.13	306.60	350.37	328.48	1.20	1.34	1.27
$B_1 Z_0$	49.33	54.00	51.66	750.18	754.17	752.17	313.82	356.90	335.36	1.23	1.35	1.29
$B_1 Z_1$	50.22	55.88	53.05	757.34	761.21	759.28	321.08	369.50	345.29	1.25	1.39	1.32
$B_2 Z_0$	50.22	56.77	53.50	761.11	765.36	763.23	326.69	379.54	353.12	1.25	1.41	1.33
$B_2 Z_1$	52.00	58.00	55.00	766.48	771.02	768.75	336.00	385.51	360.76	1.30	1.45	1.37
$CD_{(P\leq0.05)}$	**1.19**	**0.76**	**0.71**	**3.10**	**3.17**	**3.12**	**10.37**	**8.38**	**8.83**	**0.02**	**0.01**	**0.01**

Table 4.3.3: Combined effect of Ca, B and Zn on Bulb characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Number of bulbs lifted m^{-2}			Weight of bulbs lifted m^{-2} (g)			Weight of bulb lets lifted m^{-2}(g)			Bulb production ratio		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
C_0 B_0 Z_0	43.66	48.66	46.16	703.73	705.53	704.63	247.47	296.13	271.80	1.09	1.21	1.15
C_0 B_0 Z_1	44.33	49.00	46.66	705.80	707.53	706.67	272.37	312.23	292.30	1.10	1.22	1.16
C_0 B_1 Z_0	45.33	51.00	48.16	726.50	729.13	727.82	274.23	322.67	298.45	1.13	1.27	1.20
C_0 B_1 Z_1	45.66	50.00	47.83	728.90	731.53	730.22	282.03	327.77	304.90	1.14	1.25	1.19
C_0 B_2 Z_0	46.33	51.66	49.00	729.03	731.70	730.37	283.90	335.83	309.87	1.15	1.29	1.22
C_0 B_2 Z_1	47.33	53.66	50.50	739.57	743.13	741.35	287.87	338.57	313.22	1.18	1.34	1.26
C_1 B_0 Z_0	47.66	52.66	50.16	741.60	746.33	743.97	293.40	343.07	318.23	1.19	1.31	1.25
C_1 B_0 Z_1	48.33	54.33	51.33	744.30	748.33	746.32	299.97	345.37	322.67	1.20	1.35	1.28
C_1 B_1 Z_0	48.66	54.33	51.50	745.30	749.50	747.40	305.87	348.63	327.25	1.21	1.35	1.28
C_1 B_1 Z_1	49.33	54.66	52.00	760.57	764.40	762.48	312.97	355.83	334.40	1.23	1.38	1.30
C_1B_2 Z_0	49.33	55.33	52.33	769.93	774.87	772.40	322.00	366.10	344.05	1.23	1.36	1.30
C_1 B_2 Z_1	50.66	57.00	53.16	772.43	777.37	774.90	329.03	374.40	351.72	1.26	1.42	1.34
C_2 B_0 Z_0	51.00	55.33	53.16	775.23	780.17	777.70	335.57	378.57	357.07	1.27	1.38	1.32
C_2B_0 Z_1	51.00	55.33	53.83	776.83	781.97	779.40	347.47	393.50	370.48	1.27	1.38	1.32
C_2 B_1 Z_0	55.00	60.66	56.83	778.73	783.87	781.30	361.37	399.40	380.38	1.37	1.46	1.42
C_2 B_1 Z_1	55.00	58.66	57.83	782.57	787.70	785.13	368.23	424.90	396.57	1.37	1.51	1.44
C_2 B_2 Z_0	56.00	64.66	60.33	784.37	789.50	786.93	374.17	436.70	405.43	1.40	1.61	1.50
C_2 B_2 Z_1	57.33	66.00	61.66	787.43	792.57	790.00	391.10	443.57	417.33	1.43	1.65	1.54
$C.D_{(P\leq0.05)}$	**2.06**	**1.33**	**1.23**	**2.37**	**3.24**	**2.55**	**2.49**	**2.05**	**1.95**	**0.04**	**0.02**	**0.02**

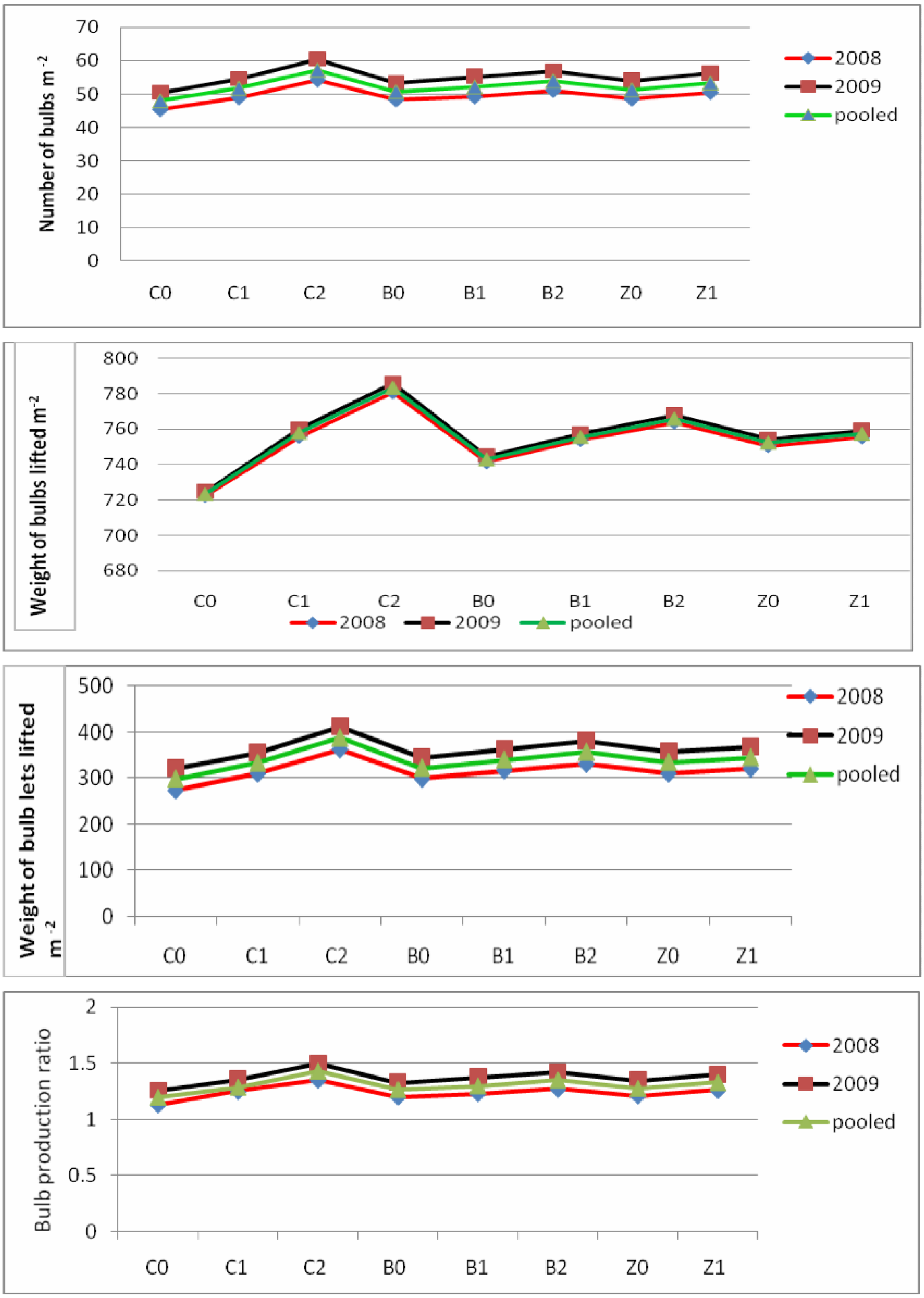


Fig. 7 : Effect of Ca, B and Zn on bulb characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Plate-4 : Tulip bulbs

comparatively minimum ratio of 1.15. Other treatment combinations resulted in bulb production ratio between these two extremes.

4.4 Vase life characters

4.4.1 Days taken to flower opening

The time taken for flower opening after the flower scapes kept in vase containing distilled water under the influence of pre planting application of various nutrients are presented in Table-4.4.1 and Fig. 8.

The differences recorded in time taken to flower opening in different calcium levels was statistically significant. Calcium at 10.00 kg ha^{-1} recorded minimum (7.02 day) to flower opening while maximum (7.91 day) was recorded at Ca 0.00 kg ha^{-1}. Although application of boron at 1.00 kg ha^{-1}(B_2) recorded lesser days (7.36) to flower opening compared to maximum number of days (7.55) with the application of boron at 0.00 kg ha^{-1} (B_0). Yet the differences were statistically non-significant.

Various levels of zinc also did not effect the number of days taken to flower opening significantly.

The two way interaction data (Table 4.4.2) revealed that the interaction between calcium and boron levels exhibited a significant variation. Lowest days to flower opening (7.00) was recorded in C_2B_2 treatment combination and the highest (8.00 day) was recorded for C_0B_0 treatment combination .

The interactive influence between calcium and zinc levels on days taken to flower opening was also significant. Lesser number of days (7.00) was recorded under C_2Z_1 treatment combinations whereas more number of days (7.94) was required for flower opening in C_0Z_0 treatment combination.

Interaction between boron and zinc were found to be non-significant.

An examination of the three way interaction data (Table 4.4.3) indicated that the differences in days taken to flower opening due to various levels of calcium, boron and zinc were significant. Minimum days (7.00) required for flower opening were noticed under calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}). While maximum days (8.00) were recorded under the lowest level of Ca (0.00 kg ha^{-1}), B (0.00 kg ha^{-1}) and Zn (0.00 kg ha^{-1}). However, $C_2B_2Z_0$, $C_2B_1Z_1$ and $C_2B_1Z_0$ were statistically at par at five per cent level of significance.

4.4.1.2 Fresh weight change (%)

The data pertaining to the fresh weight change as influenced by calcium are presented in Table-4.4.1. Different calcium levels presently tested depicted significant differences in fresh weight change. Maximum fresh weight of 13.21 g/scape was recorded in calcium (10.00 kg ha^{-1}), whereas minimum fresh weight (11.16 g/scape) was however, recorded by calcium (0.00 kg ha^{-1}).

Perusal of mean values (Table 4.4.1) for fresh weight change under different boron levels reflected that application of boron caused significant increase in fresh weight change, however, increase in application rate of boron from 0 to 1.00 kg ha^{-1} depicted significant variation in fresh weight change. The highest fresh weight (12.69%) was observed under boron at 1.00 kg ha^{-1} (B_2) and the lowest fresh weight (11.81%) was observed under boron at 0.00 kg ha^{-1} (B_0). Increase in zinc application rate from 0 to 8.00 kg ha^{-1} registered a positive impact on fresh weight while the maximum fresh weight (12.28%) was recorded under 8.00 kg zinc ha^{-1} (Z_1). Minimum fresh weight (12.12%) was recorded under 0.00 kg Zn ha^{-1}.

Various treatment combinations of two factors (Table 4.4.2) revealed that calcium and boron interaction resulted in significant variations in fresh weight change. It is vivid from the data interaction that significantly highest (13.73%) and lowest (10.69%) fresh weight changes were recorded under C_2B_2 and C_0B_0 treatment combinations, respectively. However, the interactions between treatment combinations C_2B_1 and C_2B_0 were at par at 5 per cent level of significance.

The interaction effect data clearly indicated that with the increase in rate of application of calcium and zinc there occurred a corresponding increase in fresh weight change of tulips. The fresh weight change was highest (13.29%) under C_2Z_1 and only 11.04 per cent under C_0Z_0.

Interaction between boron and zinc were also found to be significant. Maximum fresh weight change (12.75%) was recorded under B_2Z_1 followed by B_2Z_0 (12.62%), B_1Z_1(12.21%) and B_1Z_0(12.00%) whereas, minimum value (11.74%) was recorded under B_0Z_0 treatment combination.

The interaction between calcium, boron and zinc resulted significant difference in the fresh weight change (Table 4.4.3). The maximum fresh weight was recorded under $C_2B_2Z_1$ and minimum fresh weight was recorded under $C_0B_0Z_0$ with a fresh weight of 13.88 and 10.59 per cent, respectively. However, $C_2B_1Z_0$, $C_2B_0Z_1$ and $C_2B_0Z_0$ were statistically at par with each other.

4.4.3 Water uptake (g/scape)

Water uptake (g/scape) as influenced by different nutrients are presented in Table-4.4.1. Perusal of data revealed that water uptake was significantly influenced by calcium during whole period of study. Maximum water uptake was recorded by calcium 10.00 kg ha^{-1} (17.78 g/scape) followed by 5.00 kg ha^{-1} (16.90 g/scape). Minimum water uptake (16.33 g/scape) was, however, recorded by zero kg ha^{-1} of calcium. With boron, there was also a marked variation among boron levels, with 1.00 kg B ha^{-1} recorded maximum water uptake of 17.25 g/scape and zero kg ha^{-1} recorded minimum water uptake (16.66 g/scape). Zinc at 8.00 kg ha^{-1} recorded maximum water uptake (17.06 g/scape) against the minimum water uptake recorded by zero kg of Zn ha^{-1}.

Perusal of two way interaction data (Table 4.4.2) revealed that calcium and boron interaction had a significant influence on water uptake of cut tulip throughout the period of study. The trend, however, depicted that there was an increase in water uptake of cut tulip scapes with the increase in the level of calcium and boron. Maximum water uptake/scape (18.18 g) was recorded by C_2B_2 followed by C_2B_1, C_2B_0, C_1B_2 and C_1B_1 whereas, minimum water uptake was recorded under C_0B_0 (16.31 g/scape).

The interactions between different levels of calcium and zinc also influenced the water uptake significantly. The highest water uptake (17.91 g/scape) was recorded under C_2Z_1 and minimum water uptake (16.31 g/scape) was observed under C_0Z_0.

It is evident from the table that interactions between boron and zinc also influenced the water uptake. Highest (17.26 g/scape) and the lowest (16.71 g/scape) water uptake was observed with B_2Z_1 and B_0Z_0, respectively.

A favourable interaction of different levels of calcium, boron and zinc was also observed in the present study (Table 4.4.3). Maximum water uptake (18.39 g/scape) was recorded under $C_2B_2Z_1$. Minimum water uptake (16.11 g/scape) was recorded under Ca (0.00 kg ha^{-1}), B (0.00 kg ha^{-1}) and Zn (0.00 kg ha^{-1}). However, $C_2B_2Z_0$ and $C_2B_1Z_1$ were statistically at par.

4.4.4 Water loss (g/scape)

Data pertaining to the water loss as affected by calcium are presented in Table-4.4.1. There was a decrease in water loss by cut tulip scapes with the increase in calcium from 0.00 to 10.00 kg ha^{-1} to and maximum water loss of 12.33 g/scape was recorded by zero kg ha^{-1} whereas, minimum water loss of 10.91 g/scape was recorded under calcium 10.00 kg ha^{-1}.

Data on water loss as influenced by different boron levels are summarised in Table-4.4.1. Minimum water loss (11.35 g/scape) was recorded by boron (1.00 kg ha^{-1}) whereas maximum water loss of 11.89 g/scape was recorded under B_0. Data further, depicted that there was an decrease in water loss of cut tulip scapes with application of Zn at 8.00 kg ha^{-1}.

Table 4.4.1: Effect of Ca, B and Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Days taken to flower opening			Fresh weight change (%)			Water uptake (g/scape)			Water loss (g/scape)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Calcium (kg ha^{-1})												
C_0 (0)	8.00	7.83	7.91	11.32	11.45	11.16	16.41	16.54	16.33	12.55	12.35	12.33
C_1 (5.00)	7.55	7.33	7.44	12.36	12.49	12.23	16.97	17.10	16.90	11.86	11.66	11.64
C_2 (10.00)	7.05	7.00	7.02	13.24	13.37	13.21	17.87	18.00	17.78	11.11	10.91	10.91
C.D$_{(P\leq0.05)}$	**0.24**	**0.26**	**0.16**	**0.11**	**0.11**	**0.11**	**0.05**	**0.05**	**0.03**	**0.05**	**0.05**	**0.06**
Boron (kg ha^{-1})												
B_0 (0)	7.61	7.50	7.55	11.92	12.05	11.81	16.73	16.87	16.66	12.10	11.90	11.89
B_1 (0.5)	7.55	7.38	7.47	12.25	12.38	12.10	17.16	17.30	17.10	11.86	11.66	11.65
B_2 (1.00)	7.44	7.27	7.36	12.76	12.89	12.69	17.35	17.48	17.25	11.55	11.35	11.35
C.D$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.11**	**0.11**	**0.11**	**0.05**	**0.05**	**0.03**	**0.05**	**0.05**	**0.06**
Zinc (kg ha^{-1})												
Z_0 (0)	7.55	7.44	7.50	12.25	12.38	12.12	17.02	17.15	16.95	11.92	11.72	11.71
Z_1 (8.00)	7.51	7.33	7.42	12.37	12.50	12.28	17.14	17.28	17.06	11.76	11.56	11.54
C.D$_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**0.09**	**0.09**	**0.09**	**0.04**	**0.04**	**0.03**	**0.04**	**0.04**	**0.05**

NS = Non-significant

Table 4.4.2. :Interaction effect of Ca x B, Ca x Zn and B x Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Days t flower opening			Fresh weight change (%)			Water uptake (g/scape)			Water loss (g/scape)		
	2008-09	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**	**2008-09**	**2009-10**	**Pooled**
Ca x B (kg ha^{-1})												
C_0B_0	8.00	8.00	8.00	10.89	11.03	10.69	16.25	16.38	16.31	12.68	12.48	12.5
C_0 B_1	8.00	7.83	7.91	11.34	11.47	11.13	16.48	16.61	16.54	12.53	12.33	12.3
C_0 B_2	8.00	7.66	7.83	11.73	11.86	11.66	16.50	16.63	16.56	12.43	12.23	12.2
C_1B_0	7.66	7.33	7.5	11.97	12.10	11.86	16.56	16.70	16.63	12.2	12	11.96
C_1 B_1	7.66	7.50	7.58	12.38	12.51	12.17	17.11	17.25	17.05	11.86	11.66	11.65
C_1 B_2	7.33	7.16	7.25	12.74	12.88	12.68	17.23	17.36	17.16	11.51	11.31	11.31
C_2 B_0	7.16	7.00	7.08	12.89	13.03	12.88	17.40	17.53	17.33	11.43	11.23	11.21
C_2 B_1	7.00	7.00	7.00	13.02	13.16	13.01	17.90	18.03	17.83	11.2	11	11
C_2 B_2	7.00	7.00	7.00	13.81	13.94	13.73	18.31	18.45	18.18	10.71	10.51	10.53
CD$_{(P\leq 0.05)}$	0.43	0.45	0.28	0.20	0.20	0.20	0.09	0.09	0.06	**0.10**	**0.10**	**0.11**
Ca x Zn (kg ha^{-1})												
C_0Z_0	8.00	7.88	7.94	11.24	11.37	11.04	16.38	16.52	16.31	12.6	12.4	12.38
C_0Z_1	8.00	7.77	7.88	11.41	11.54	11.27	16.43	16.56	16.35	12.5	12.3	12.28
C_1Z_0	7.55	7.22	7.38	12.33	12.46	12.18	16.94	17.07	16.88	11.96	11.76	11.75
C_1Z_1	7.55	7.44	7.5	12.40	12.53	12.28	17.00	17.13	16.92	11.75	11.55	11.53
C_2Z_0	7.11	7.00	7.05	13.18	13.31	13.13	17.73	17.86	17.65	11.2	11	11.01
C_2Z_1	7.00	7.00	7.00	13.30	13.44	13.29	18.01	18.14	17.91	11.03	10.83	10.81
CD$_{(P\leq 0.05)}$	**0.35**	**0.37**	**0.23**	**0.16**	**0.16**	**0.16**	**0.07**	**0.07**	**0.05**	**0.08**	**0.08**	**0.09**
B x Zn (kg ha^{-1})												
B_0 Z_0	7.66	7.55	7.61	11.87	12.00	11.74	16.77	16.91	16.71	12.14	11.94	11.93
B_0 Z_1	7.55	7.33	7.44	11.97	12.10	11.88	16.70	16.83	16.61	12.06	11.86	11.85
B_1 Z_0	7.55	7.44	7.5	12.17	12.30	12.00	17.03	17.16	16.98	11.98	11.78	11.79
B_1 Z_1	7.55	7.44	7.5	12.33	12.46	12.21	17.30	17.43	17.21	11.74	11.54	11.5
B_2 Z_0	7.44	7.22	7.33	12.71	12.84	12.62	17.33	17.46	17.25	11.63	11.43	11.41
B_2 Z_1	7.44	7.33	7.38	12.81	12.95	12.75	17.36	17.50	17.26	11.47	11.27	11.28
CD$_{(P\leq 0.05)}$	**NS**	**NS**	**NS**	**0.16**	**0.16**	**0.16**	**0.07**	**0.07**	**0.05**	**0.08**	**0.08**	**0.09**

NS = Non-significant

Table 4.4.3: Combined effect of Ca, B and Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Days to flower opening			Fresh weight change (%)			Water uptake (g/scape)			Water loss (g/scape)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
$C_0 B_0 Z_0$	8.00	8.00	8.00	10.83	10.96	10.59	16.20	16.33	16.11	12.73	12.53	12.55
$C_0 B_0 Z_1$	8.00	8.00	8.00	10.96	11.10	10.80	16.30	16.43	16.21	12.63	12.43	12.45
$C_0 B_1 Z_0$	8.00	8.00	8.00	11.18	11.31	10.91	16.46	16.6	16.41	12.60	12.40	12.38
$C_0 B_1 Z_1$	8.00	7.66	7.83	11.50	11.64	11.34	16.50	16.63	16.41	12.46	12.26	12.21
$C_0 B_2 Z_0$	8.00	7.66	7.83	11.71	11.84	11.63	16.50	16.63	16.41	12.46	12.26	12.21
$C_0 B_2 Z_1$	8.00	7.66	7.83	11.76	11.89	11.68	16.50	16.63	16.41	12.40	12.20	12.18
$C_1 B_0 Z_0$	7.66	7.33	7.50	11.92	12.06	11.82	16.53	16.66	16.45	12.23	12.03	11.98
$C_1 B_0 Z_1$	7.66	7.33	7.50	12.01	12.15	11.90	16.60	16.73	16.55	12.16	11.96	11.95
$C_1 B_1 Z_0$	7.66	7.33	7.50	12.33	12.47	12.10	17.10	17.23	17.05	12.10	11.90	11.91
$C_1 B_1 Z_1$	7.33	7.00	7.16	12.42	12.55	12.24	17.13	17.26	17.05	11.63	11.43	11.38
$C_1B_2 Z_0$	7.33	7.00	7.33	12.73	12.86	12.64	17.20	17.33	17.15	11.56	11.36	11.35
$C_1 B_2 Z_1$	7.33	7.00	7.16	12.76	12.89	12.71	17.26	17.4	17.18	11.46	11.26	11.28
$C_2 B_0 Z_0$	7.33	7.00	7.16	12.85	12.99	12.82	17.36	17.5	17.28	11.46	11.26	11.28
$C_2B_0 Z_1$	7.33	7.66	7.50	12.94	13.07	12.94	17.43	17.56	17.38	11.40	11.20	11.15
$C_2 B_1 Z_0$	7.00	7.00	7.00	12.99	13.13	12.98	17.53	17.66	17.48	11.26	11.06	11.08
$C_2 B_1 Z_1$	7.00	7.00	7.00	13.06	13.19	13.04	18.26	18.4	18.33	11.13	10.93	10.91
$C_2 B_2 Z_0$	7.00	7.00	7.00	13.69	13.83	13.59	18.30	18.43	18.30	10.86	10.66	10.68
$C_2 B_2 Z_1$	7.00	7.00	7.00	13.92	14.06	13.88	18.33	18.46	18.39	10.56	10.36	10.38
C.D$_{(P\leq 0.05)}$	**0.60**	**0.64**	**0.40**	**0.28**	**0.28**	**0.28**	**0.12**	**0.12**	**0.09**	**0.14**	**0.14**	**0.15**

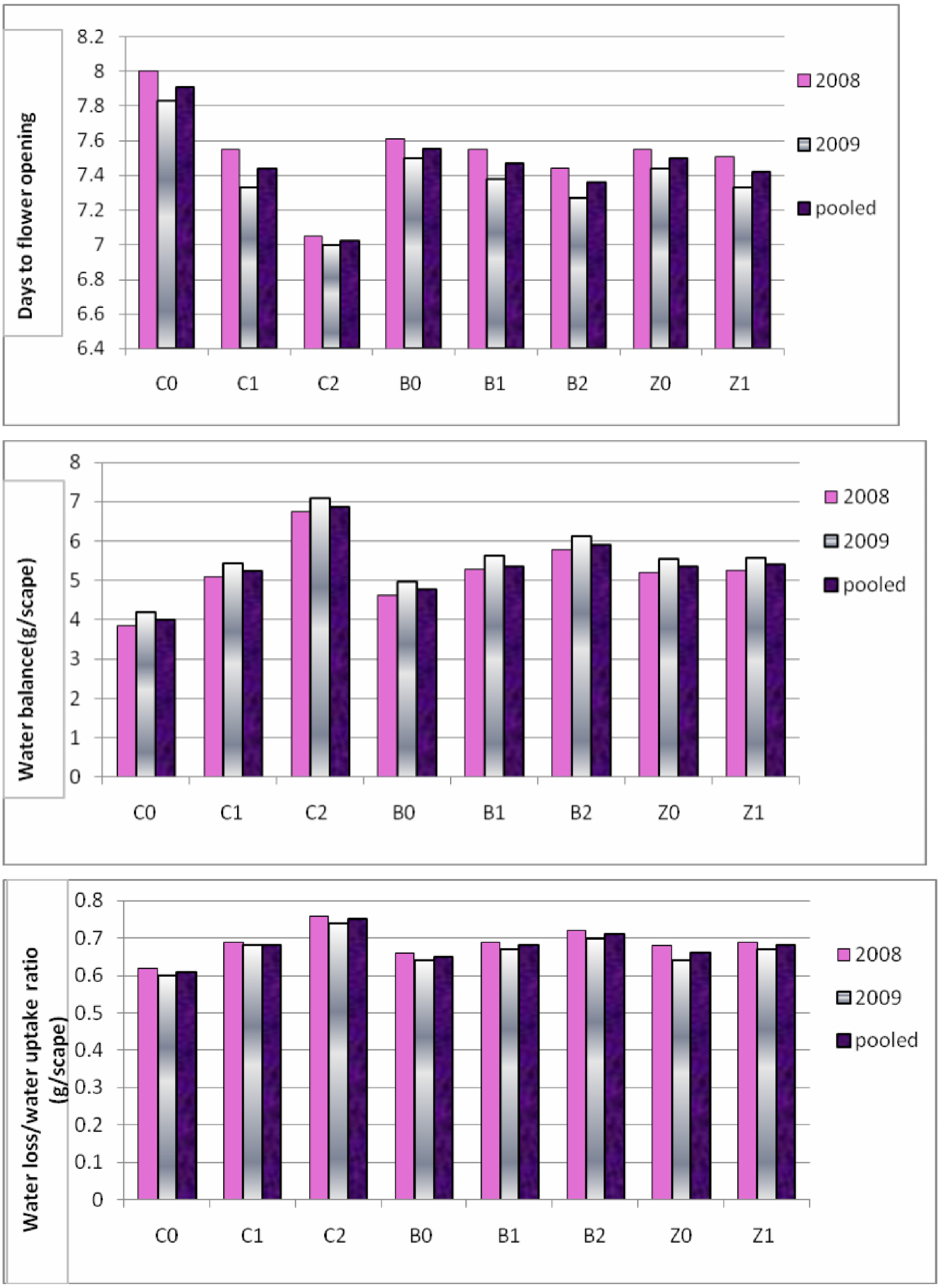


Fig. 8 : Effect of Ca, B and Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10

The interaction effects of two factors together (Table 4.4.2) revealed that the application of calcium and boron at 10.00 and 1.00 kg ha^{-1}, respectively had a significant impact on water loss/scape. The treatment combination C_2B_2 recorded the minimum water loss (10.53 g/scape) whereas the maximum (12.50 g/scape) water loss was recorded under C_0B_0.

The interaction between calcium and zinc levels proved to be beneficial in decreasing the water loss. The treatment combination C_2Z_1 recorded the minimum water loss (10.81 g/scape) whereas, maximum (12.38 g/scape) was recorded under C_0Z_0. The results with regard to B x Zn followed the same trend with boron and zinc at highest level of 1.00 and 8.00 kg ha^{-1} noticed the minimum water loss of 11.28 g/scape whereas maximum water loss (11.93 g/scape) was recorded under B_0Z_0 with 0.00 kg of B and Zn, respectively.

Perusal of mean values for water loss (Table 4.4.3) under different levels of calcium, boron and zinc revealed that application of Ca (10.00 kg ha), B (1.00 kg ha^{-1}) and Zn (8.00 kg ha^{-1}) had a significant impact on the water loss. The minimum water loss (10.38 g/scape) was recorded under $C_2B_2Z_1$ treatment combination followed by $C_2B_2Z_0$ (10.68 g/scape) and $C_2B_1Z_1$ (10.91 g/scape), whereas maximum water loss of 12.55 g/scape was recorded under $C_0B_0Z_0$ treatment combination.

4.4.5 Water balance (g/scape)

Analysis of variance indicated that calcium, boron and zinc levels resulted a significant variation in water balance (Table-4.4.4 and Fig. 8).

The water balance produced by different nutrients differed statistically at 5 per cent level of significance. Maximum water balance (6.86 g/scape) was recorded in calcium (10.00 kg ha^{-1}) followed by 5.25 in calcium (5.00 kg ha^{-1}) and minimum water balance (3.99 g/scape) was recorded under calcium (0.00 kg ha^{-1}).

Perusal of mean values for water balance under different boron levels revealed that application of boron had a significant positive impact on water balance. The highest water balance (5.90 g/scape) was observed under 1.00 kg B ha^{-1} and lowest (4.76 g/scape) was recorded under 0.00 kg ha^{-1} boron.

Application of Zn 8.00 kg ha^{-1} increased water balance (g/scape) significantly and exhibited the maximum water balance of 5.40 g/scape against minimum (5.34 g/scape) with 0.00 kg Zn ha^{-1}.

Two way interaction data (Table 4.4.5) showed that the interactive influence of calcium and boron also had a significant impact on water balance. Calcium at 10.00 kg ha^{-1} along with highest level of boron (1.00 kg ha^{-1}) recorded highest water balance per scape (7.65 g), whereas minimum water balance (3.66 g/scape) was observed with C_0B_0 with calcium at 0.00 kg ha^{-1} along with boron 0.00 kg ha^{-1}.

The interaction between calcium and zinc significantly affected the water balance. Highest water balance (7.1 g/scape) was recorded under C_2Z_1 followed by C_2Z_0 and C_1Z_1. However, the interaction between calcium and zinc at 0.00 kg ha^{-1} respectively recorded lowest water balance.

No significant difference in the water balance was recorded under boron and zinc interaction.

The interaction between calcium, boron and zinc levels exhibited a significant influence on the water balance (Table 4.4.6). The treatment combination of $C_2B_2Z_1$ produced the highest water balance (7.80 g/scape) which was significantly more than that of $C_0B_0Z_0$ treatment combination

4.4.6 Water loss/water uptake ratio

Data in Table-4.4.4 and Fig. 8 revealed discernible variation in water loss/water uptake ratio due to various nutrient manipulations. Under the calcium applied plants (10.00 kg ha^{-1}) the water loss/water uptake ratio was 0.75 that was significantly higher as compared to the water loss /uptake ratio of 0.61 under control. The values of water loss/uptake ratio were 0.65, 0.68 and 0.71 under B_0, B_1 and B_2 treatments, which were found to be statistically significant.

However, it is evident from the table that zinc could not exert any significant difference in water loss/water uptake ratio.

The interaction effect (Table 4.4.5) revealed that the interaction between calcium and boron increased the water loss / water uptake ratio significantly from 0.57 to 0.77 with enhancement in calcium and boron rate from 0.00 to 10.00 and 0.00 to 1.00 kg ha^{-1}, respectively.

Calcium and zinc interaction was found to significantly influence the water loss/water uptake ratio. With no application of Ca × Zn, the ratio remained virtually 0.60, however, with supply of calcium (10.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}), the water loss / water uptake ratio markedly increased up to 0.76.

The interaction between boron and zinc did not cause any significant variation in water loss / water uptake ratio. The interaction between calcium, boron and zinc were also found to be insignificant.

4.4.7 Flower diameter (cm)

Data (Table-4.4.4 and Fig. 9) showed that the flower diameter under vase was significantly influenced by various treatments under study.

Highest flower diameter 10.42 cm was recorded in calcium (10.00 kg ha^{-1}), whereas, the smallest flowers with a diameter of 8.00 cm were observed in calcium (0.00 kg ha^{-1}).

Boron application also affected the flower diameter. The tulips receiving B dose of 1.00 kg ha^{-1} increased the flower diameter by 9.76 cm compared to no application of B (8.55cm). The crop receiving zinc dose of 8.00 kg ha^{-1} resulted in largest flowers (9.37cm) compared to no application of zinc (9.10 cm).

Perusal of interaction effect data (Table 4.4.5) revealed that interaction between different levels of calcium and boron caused a significant increase in flower diameter. The maximum flower diameter (11.07 cm) was observed in C_2B_2 with 10 kg Ca ha^{-1} and 8.00 kg of B ha^{-1} whereas nearly half of this (6.95 cm) was noticed in C_0B_0 with 0.00 kg ha^{-1} of calcium and boron, respectively.

The interaction between calcium and zinc levels were also found significant. Maximum diameter of 10.61 cm was observed for calcium with 10.00 kg ha^{-1} and boron with 1.00 kg ha^{-1}, whileas the minimum flower diameter of 7.72 cm was observed under C_0Z_0 treatment combination.

Under the interactive influence of boron and zinc, maximum flower diameter (9.95 cm) was recorded with calcium at 10.00 kg ha^{-1} with zinc at 8.00 kg ha^{-1} whereas minimum flower diameter (8.31 cm) was recorded with zero kg ha^{-1} of calcium and zinc, respectively.

The magnitude of superiority of $C_2B_2Z_1$ over $C_0B_0Z_0$ with regard to flower diameter was 11.46 cm and 6.31 cm, respectively. However, $C_2B_1Z_1$ and $C_2B_1Z_0$ were statistically at par at 5 per cent level of significance.

4.4.8 Scape length (cm)

Discernible variations were observed in scape length under vase due to different calcium levels (Table-4.4.4 and Fig. 9). The mean values for scape length in three levels of calcium indicated maximum scape length of 28.93 cm under C_2 treatment and minimum (26.47 cm) under C_0 treatment.

Increase in the application of boron from 0.00 to 1.00 kg ha^{-1} caused an increase in scape length. The data indicated highest scape length of 28.22 cm with 1.00 kg B ha^{-1} followed by 27.69 cm under B_1 and lowest (27.10 cm) scape length recorded under B_0. Application of zinc produced similar effects, depicted maximum scape length (27.86 cm) with the application of zinc at 8.00 kg ha^{-1}.

The influence of interaction between calcium and boron levels in terms of scape length were significant. Maximum scape length (29.74 cm) was observed in calcium (10.00 kg ha^{-1}) with boron (1.00 kg ha^{-1}) whereas (25.65 cm) was recorded for C_0B_0 with 0.00 kg ha^{-1} of calcium and boron (Table 4.4.5).

The interaction between different levels of calcium and zinc also influenced the scape length significantly. Highest scape length (29.16 cm) was recorded for C_2Z_1 treatment combination with calcium at 10.00 kg $ha^{-1}$and zinc at 8.00 kg ha^{-1} and the lowest scape length (26.21 cm) was observed in C_0Z_0.

Data further revealed significantly maximum scape length (28.35 cm) under the influence of B_2Z_1 at 1.00 kg ha^{-1} of boron alongwith zinc at 8.00 kg ha^{-1} whereas, the minimum scape length (26.88 cm) was recorded under B_0Z_0.

Under the interactive influence of calcium, boron and zinc, maximum scape length (32.80 cm) was recorded with calcium (10.00 kg), boron (1.00 kg) and zinc at 8.00 kg ha^{-1}, respectively. Whereas, minimum scape length of 28.94 cm was observed under treatment combination of $C_0B_0Z_0$ (Table 4.4.6).

4.4.9 Vase life (day)

The vase life registered under different nutrient levels differed statistically at 5 per cent level of significance (Table-4.4.4 and Fig. 9). Maximum vase life of 7.85 days was recorded in calcium (10.00 kg ha^{-1}) followed by 7.70 days in calcium (5.00 kg ha^{-1}) while minimum vase life of 7.35 day was recorded under C_0 with no calcium applied plants.

Perusal of mean values for vase life under different boron levels revealed that the boron had a significant positive impact on the vase-life. The maximum vase life (7.77 day) was observed under boron (1.00 kg ha^{-1}) followed by 0.50 kg ha^{-1} (7.65 day) and minimum (7.48 day) was recorded under 0.00 kg B ha^{-1}.

Application of Zn 8.00 kg ha^{-1} registered a significant increase in vase-life. Maximum vase life of 7.65 day was observed with 8.00 kg Zn ha^{-1} and minimum vase life (7.61 day) was recorded under 0.00 kg Zn ha^{-1}.

Effect of two nutrients together (Table 4.4.5) showed that the interaction between calcium and boron significantly affected the vase-life. Maximum vase life (7.96 day) was recorded under C_2B_2 followed by 7.80 days under C_2B_1. However, the interactions between C_2B_1, C_2B_0 and C_1B_2 were statistically at par.

Table 4.4.4: Effect of Ca, B and Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Treatment	Water balance (g/scape)			Water loss/water uptake ratio (g/scape)			Flower diameter (cm)			Scape length (cm)			Vase life (day)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Calcium (kg ha^{-1})															
C_0 (0)	3.86	4.19	3.99	0.62	0.60	0.61	8.07	7.93	8.00	26.16	26.78	26.47	7.36	7.34	7.35
C_1 (5.00)	5.10	5.43	5.25	0.69	0.68	0.68	9.40	9.19	9.29	27.28	27.95	27.62	7.70	7.70	7.70
C_2 (10.00)	6.75	7.08	6.86	0.76	0.74	0.75	10.37	10.47	10.42	28.54	29.31	28.93	7.85	7.85	7.85
C.D$_{(P\leq0.05)}$	**0.06**	**0.06**	**0.02**	**0.003**	**0.003**	**0.001**	**0.18**	**0.11**	**0.08**	**0.24**	**0.23**	**0.20**	**0.05**	**0.05**	**0.05**
Boron (kg ha^{-1})															
B_0 (0)	4.62	4.96	4.76	0.66	0.64	0.65	8.57	8.54	8.55	26.77	27.44	27.10	7.48	7.48	7.48
B_1 (0.5)	5.29	5.63	5.36	0.69	0.67	0.68	9.47	9.39	9.40	27.35	28.03	27.69	7.65	7.64	7.65
B_2 (1.00)	5.79	6.12	5.9	0.72	0.70	0.71	9.80	9.72	9.76	27.87	28.57	28.22	7.77	7.76	7.77
C.D$_{(P\leq0.05)}$	**0.06**	**0.06**	**0.02**	**0.003**	**0.003**	**0.001**	**0.18**	**0.11**	**0.08**	**0.24**	**0.23**	**0.20**	**0.05**	**0.05**	**0.05**
Zinc (kg ha^{-1})															
Z_0 (0)	5.21	5.55	5.34	0.68	0.64	0.66	9.17	9.04	9.10	27.15	27.82	27.48	7.61	7.61	7.61
Z_1 (8.00)	5.25	5.58	5.40	0.69	0.67	0.68	9.39	9.36	9.37	27.51	28.21	27.86	7.66	7.65	7.65
C.D$_{(P\leq0.05)}$	**0.05**	**0.05**	**0.02**	**NS**	**NS**	**NS**	**0.15**	**0.09**	**0.06**	**0.20**	**0.19**	**0.16**	**0.03**	**0.03**	**0.03**

NS = Non-significant

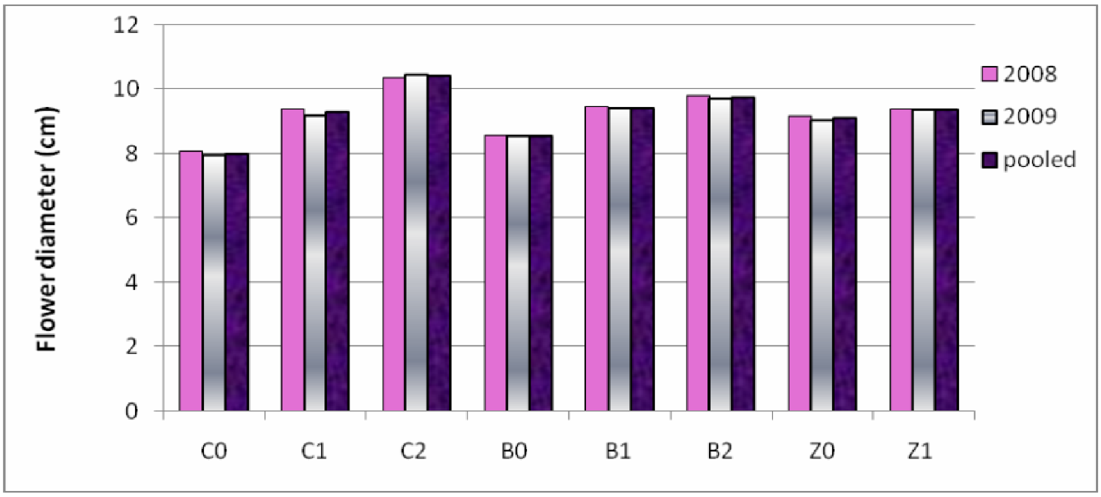
Table 4.4.5. : Interaction effect of Ca x B, Ca x Zn and B x Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

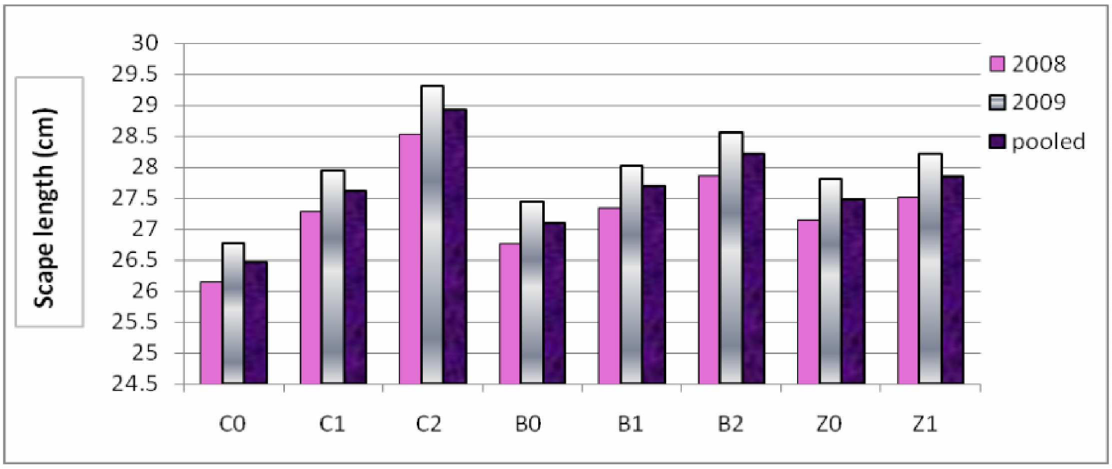
Treatment	Water balance (g/scape)			Water loss/Water uptake ratio			Flower diameter (cm)			Scape length (cm)			Vase life (cm)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
Ca x B (kg ha^{-1})															
C_0B_0	3.57	3.9	3.66	0.58	0.56	0.57	7.01	6.88	6.95	25.34	25.96	25.65	7.06	7.06	7.06
$C_0 B_1$	3.95	4.28	4.11	0.62	0.61	0.61	8.43	8.33	8.38	26.31	26.92	26.61	7.46	7.43	7.45
$C_0 B_2$	4.07	4.4	4.21	0.65	0.64	0.64	8.76	8.60	8.68	26.85	27.46	27.15	7.56	7.53	7.55
C_1B_0	4.36	4.7	4.54	0.66	0.65	0.65	8.98	8.81	8.90	27.16	27.80	27.48	7.60	7.60	7.60
$C_1 B_1$	5.25	5.59	5.4	0.69	0.67	0.68	9.60	9.48	9.54	27.28	27.94	27.61	7.70	7.70	7.70
$C_1 B_2$	5.72	6.05	5.85	0.73	0.71	0.72	9.61	9.28	9.45	27.41	28.12	27.76	7.80	7.80	7.80
$C_2 B_0$	5.97	6.3	6.12	0.75	0.73	0.74	9.71	9.93	9.82	27.81	28.57	28.19	7.80	7.80	7.80
$C_2 B_1$	6.70	7.03	6.83	0.76	0.74	0.74	10.36	10.40	10.38	28.46	29.24	28.85	7.80	7.80	7.80
$C_2 B_2$	7.60	7.94	7.65	0.78	0.76	0.77	11.05	11.10	11.07	29.36	30.13	29.74	7.96	7.96	7.96
$CD_{(P\leq0.05)}$	**0.12**	**0.11**	**0.04**	**0.005**	**0.005**	**0.002**	**0.32**	**0.20**	**0.14**	**0.43**	**0.40**	**0.40**	**0.09**	**0.09**	**0.09**
Ca x Zn (kg ha^{-1})															
C_0Z_0	3.78	4.12	3.93	0.61	0.59	0.60	7.75	7.68	7.72	25.90	26.52	26.21	7.31	7.31	7.31
C_0Z_1	3.93	4.26	4.07	0.63	0.61	0.62	8.38	8.18	8.28	26.42	27.04	26.73	7.42	7.37	7.40
C_1Z_0	4.98	5.31	5.13	0.69	0.67	0.68	9.25	9.22	9.23	27.22	27.87	27.54	7.68	7.68	7.68
C_1Z_1	5.25	5.58	5.39	0.70	0.68	0.69	9.54	9.16	9.35	27.34	28.04	27.69	7.71	7.71	7.71
C_2Z_0	6.53	6.86	6.64	0.70	0.68	0.69	10.22	10.26	10.24	28.31	29.08	28.7	7.84	7.84	7.84
C_2Z_1	6.98	7.31	7.1	0.77	0.75	0.76	10.53	10.68	10.61	28.77	29.55	29.16	7.86	7.86	7.86
$CD_{(P\leq0.05)}$	**0.09**	**0.09**	**0.03**	**0.004**	**0.004**	**0.002**	**0.08**	**0.16**	**0.11**	**0.35**	**0.33**	**0.14**	**0.07**	**0.07**	**0.07**
B x Zn (kg ha^{-1})															
$B_0 Z_0$	4.56	4.89	4.68	0.66	0.64	0.65	8.34	8.28	8.31	26.55	27.21	26.88	7.46	7.46	7.46
$B_0 Z_1$	4.71	5.05	4.86	0.67	0.66	0.66	8.80	8.80	8.80	26.99	27.68	27.33	7.51	7.51	7.51
$B_1 Z_0$	5.05	5.38	5.19	0.67	0.65	0.66	9.37	9.40	9.38	27.15	27.83	27.49	7.62	7.62	7.62
$B_1 Z_1$	5.56	5.89	5.71	0.70	0.68	0.69	9.56	9.27	9.42	27.55	28.24	27.89	7.68	7.66	7.67
$B_2 Z_0$	5.7	6.03	5.84	0.71	0.70	0.70	9.61	9.55	9.58	27.74	28.43	28.09	7.75	7.75	7.75
$B_2 Z_1$	5.89	6.23	5.98	0.72	0.70	0.71	10.00	9.90	9.95	27.99	28.71	28.35	7.80	7.77	7.78
$CD_{(P\leq0.05)}$	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.08**	**0.16**	**0.11**	**0.35**	**0.33**	**0.14**	**0.07**	**0.07**	**0.07**

NS = Non-significant

Table 4.4.6: Combined effect of Ca, B and Zn on vase life characters of tulip cv. Apeldoorn (2008-09-2009-10)

Treatment	Water balance (g/scape)			Water loss/water uptake			Flower diameter (cm)			Scape length (cm)			Vase life (day)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
$C_0 B_0 Z_0$	3.47	3.80	3.56	0.57	0.56	0.57	6.26	6.36	6.31	28.72	29.16	28.94	7.00	7.00	7.00
$C_0 B_0 Z_1$	3.67	4.00	3.76	0.59	0.57	0.58	7.76	7.40	7.58	29.64	30.17	29.9	7.13	7.13	7.13
$C_0 B_1 Z_0$	3.86	4.20	4.03	0.60	0.59	0.60	8.33	8.23	8.28	29.72	30.26	29.99	7.40	7.40	7.40
$C_0 B_1 Z_1$	4.04	4.37	4.20	0.64	0.62	0.63	8.53	8.43	8.48	29.8	30.27	30.04	7.53	7.53	7.53
$C_0 B_2 Z_0$	4.04	4.37	4.20	0.65	0.63	0.64	8.66	8.46	8.56	29.85	30.45	30.15	7.53	7.46	7.50
$C_0 B_2 Z_1$	4.10	4.43	4.23	0.66	0.64	0.65	8.83	8.86	8.85	29.88	30.48	30.18	7.60	7.60	7.60
$C_1 B_0 Z_0$	4.30	4.63	4.47	0.66	0.64	0.65	8.86	8.73	8.80	32.73	30.5	33.11	7.60	7.60	7.60
$C_1 B_0 Z_1$	4.44	4.77	4.60	0.67	0.66	0.66	9.13	8.76	8.95	28.24	28.91	28.42	7.60	7.53	7.56
$C_1 B_1 Z_0$	5.00	5.33	5.14	0.67	0.65	0.66	9.26	9.30	9.28	28.54	29.92	28.73	7.66	7.66	7.66
$C_1 B_1 Z_1$	5.50	5.83	5.67	0.70	0.69	0.69	9.53	9.46	9.50	29.46	30.12	29.69	7.73	7.73	7.73
$C_1B_2 Z_0$	5.64	5.97	5.80	0.73	0.72	0.72	9.63	9.73	9.68	29.59	30.6	29.86	7.80	7.80	7.80
$C_1 B_2 Z_1$	5.80	6.14	5.90	0.73	0.71	0.72	9.66	9.50	9.58	30.06	30.82	30.33	7.80	7.80	7.80
$C_2 B_0 Z_0$	5.90	6.24	6.00	0.75	0.73	0.74	9.80	10.13	9.96	30.28	30.88	30.55	7.80	7.80	7.80
$C_2B_0 Z_1$	6.03	6.36	6.23	0.75	0.73	0.74	9.96	9.26	9.61	30.35	31.03	30.62	7.80	7.80	7.80
$C_2 B_1 Z_0$	6.27	6.60	6.40	0.75	0.73	0.74	10.33	10.46	10.40	30.46	31.34	30.75	7.80	7.80	7.80
$C_2 B_1 Z_1$	7.13	7.47	7.27	0.76	0.74	0.75	10.40	10.33	10.36	30.58	32.32	30.96	7.80	7.80	7.80
$C_2 B_2 Z_0$	7.44	7.77	7.50	0.77	0.75	0.76	10.63	10.73	10.68	31.55	32.32	31.93	7.93	7.93	7.93
$C_2 B_2 Z_1$	7.77	8.10	7.80	0.78	0.76	0.77	11.46	11.46	11.46	32.42	33.18	32.80	8.00	8.00	8.00
C.D$_{(P\leq0.05)}$	**0.17**	**0.15**	**0.06**	**NS**	**NS**	**NS**	**0.45**	**0.28**	**0.20**	**0.49**	**0.97**	**0.70**	**0.12**	**0.12**	**0.12**





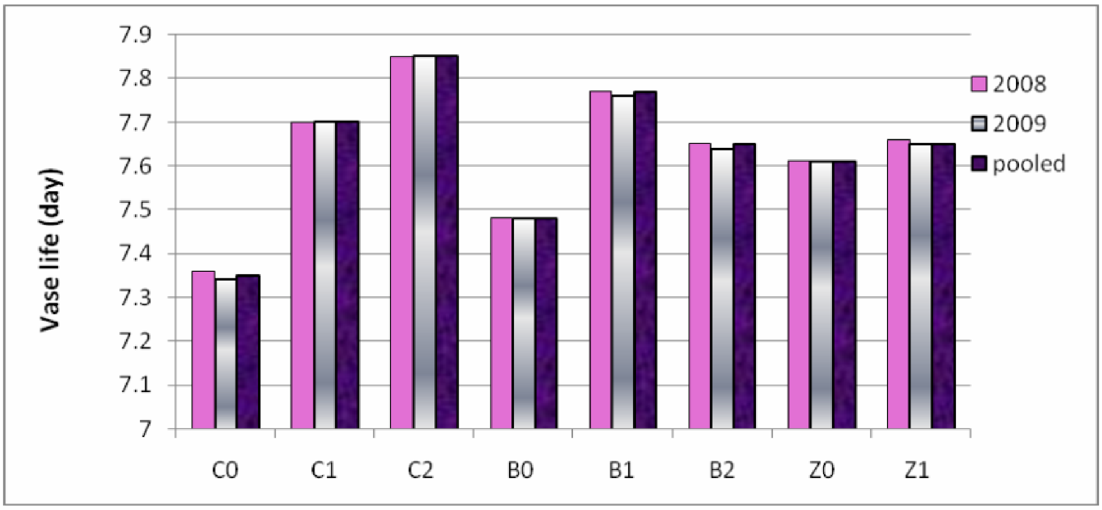


Fig. 9 : Effect of Ca, B and Zn on vase life characters of tulip cv. Apeldoorn (2008-09 to 2009-10)

Plate-5 : Vase life

Though the vase life was influenced by the interaction between calcium and zinc, yet the treatment combinations of C_2Z_1 and C_2Z_0 were statistically at par with each other.

Various treatment combinations of boron and zinc resulted in significant variation in vase-life. It is vivid from the data (Table 4.4.5) that significantly maximum (7.78 day) and minimum (7.46 day) vase life were recorded under B_2Z_1 and B_0Z_0 treatment combinations, respectively.

The difference recorded in vase life in different nutrient levels was statistically significant (Table 4.4.6). Various levels of calcium, boron and zinc influence the vase life character significantly. The application of Ca (10.00 kg ha^{-1}) with boron (1.00 kg ha^{-1}) and Zn (8.00 kg ha^{-1}) recorded maximum vase life (8.00 day) compared to minimum vase life of 7.00 days under the treatment combination of $C_0B_0Z_0$. However, $C_2B_1Z_1$, $C_2B_1Z_0$, and $C_2B_0Z_1$ treatment combinations were statistically at par with each other.

4.5 Relative economics

On the basis of pooled data of two years (2008-09 and 2009-10) cost of production of various nutrients (treatment wise) per hectare basis for Tulip cv. “Apeldoorn” using best nutrient combinations based upon the results obtained in the present investigation, were calculated under Kashmir conditions (Table 4.5.1) and got the maximum returns. Total returns by selling the flower @ Rs.12/scape and bulb @ Rs.8/bulb were under treatment combination of $C_2B_2Z_1$, which gave maximum net income of Rs 7569100 with cost : benefit ratio of 1.47.

Table 4.5.1 : Relative economics (2008-09 to 2009-10)

Treatments	Returns from yield/ha			Gross income/ha	Total cost of cultivation/ha	Net income/ha	Cost benefit ratio
	Flowers	Bulbs	Bulb lets				
C_0 B_0 Z_0	3000000	5539200	1350000	9889200	5157500	4731700	0.95
C_0 B_0 Z_1	3000000	5599200	1440000	10039200	5141300	4897900	0.95
C_0 B_1 Z_0	3200000	5779200	1320000	10299200	5140500	5158700	1.00
C_0 B_1 Z_1	3200000	5739600	1320000	10259600	5148700	5110900	1.00
C_0 B_2 Z_0	3300000	5880000	1200000	10380000	5147900	5232100	1.01
C_0 B_2 Z_1	3600000	6060000	1560000	11220000	5150900	6069100	1.17
C_1 B_0 Z_0	3600000	6019200	1200000	10819200	5150100	5669100	1.10
C_1 B_0 Z_1	3400000	6159600	1200000	10759600	5149400	5610200	1.08
C_1 B_1 Z_0	3700000	6180000	1200000	11080000	5158200	5921800	1.15
C_1 B_1 Z_1	3750000	6240000	1200000	11190000	5133900	6056100	1.18
C_1B_2 Z_0	3800000	6279600	1200000	11279600	5159000	6120600	1.19
C_1 B_2 Z_1	3800000	6459600	1200000	11459600	5144300	6315300	1.22
C_2 B_0 Z_0	3800000	6379200	1200000	11379200	5133200	6246000	1.21
C_2B_0 Z_1	3900000	6379200	1200000	11479200	5151600	6327600	1.22
C_2 B_1 Z_0	4000000	6939600	1200000	12139600	5142100	6997500	1.36
C_2 B_1 Z_1	4000000	6819600	1080000	11899600	5142700	6756900	1.31
C_2 B_2 Z_0	4000000	7239600	1200000	12439600	5134700	7304900	1.42
C_2 B_2 Z_1	4000000	7399200	1320000	12719200	5150100	7569100	1.47

CHAPTER – 5

DISCUSSION

Various experimental observations were thoroughly screened and elaborated in Chapter-4. The most relevant and beneficial findings of the present study are comprehensively dealt and discussed here under in the light of available literature.

5.1 Growth and physiological characters

5.1.1 Days taken to bulb sprouting and bulb sprouting percentage

A critical analysis of the data reveals that the application of nutrients have remarkable effect on growth and physiological parameters of tulip. The most important factor that affects the bulb sprouting in tulips is temperature. As all the treatment combinations in the present study encountered similar conditions, bulb sprouting in these would be expected to have taken place at around the same time. This is reflected in the non-significant differences among different treatment combinations in terms of days to bulb sprouting. The studies are commensurate with the findings of Benschop (1980) who noticed variations in terms of days to bulb sprouting and bulb sprouting per cent. He described that initial days of planting until emergence, root growth occurs and the increase of the shoot is low. However studies on crop (De-Hertogh and Le-Nard, 1993; Peterburgskii and Lyashkoi, 1997) revealed that preplanting treatment of B and Zn induced an earlier sprouting with increased sprouting percentage and vigour of the tulip plant.

5.1.2 Plant height, number of leaves, wrapper leaf area

Plant height which is the important index of general growth performance of the plant which was found to be increased by the application of calcium, boron and zinc with different levels individually as well as in combination. Several workers have also reported the similar findings. Calcium and boron have been reported to affect plant growth due to their role in cell division and expansion (Marschner, 1995). In tulip, Ca deficiency was associated with a decrease in plant height (Nelson and Niedziela, 1998b), probably because of Ca activates the enzymes involved in mitosis and cytokinesis, as reported by Gislerod (1999). Boron participates in the synthesis of uracil, which is involved in RNA formation and promotes cell division and differentiation, thus maintaining the meristematic activity and vegetative growth (Marschner, 1995; Jones, 2003). The plant height and number of leaves showed a linear increase with the application of boron at 1.00 kg ha^{-1} among all the levels, which might be due to the uptake of boron in optimum dose at the critical development stage. Boron performs an essential role in the biosynthesis of auxins within the plant meristem, leading to increased translocation of sugars as a result of auxin stimulated growth. Similar observations were made earlier by Rajput *et al.* (2003) in African marigold and Karthikeyan *et al.* (2009) in carnation.

Boron at 1.00 kg ha^{-1} increased plant height in tulip, the marked increase in plant height treated with boron was recorded due to fact that it is attributed to the enhanced cell division, protein metabolism and salt absorption. The findings discussed above are in conformity with reports made by Naik *et al*. (2009) in gladiolus.

Salazar-Orozco (2010) reported statistically significant differences in quality variables such as height and leaf area of lily with Ca^{2+}. With the increasing levels of boron, the plant height and number of leaves increased (Khan, 2000; Nath and Biswas, 2002). It has also been reported that length of leaf was significantly increased with calcium, boron and zinc in gladiolus (Kumar *et al.* 2003). The effect of soil applied Zn was slower, but it was more effective in increasing plant height and leaf and bud count in lillium and chrysanthemum (Asif, 1974). Zinc at 8.00 kg ha^{-1}increased plant height, might be due to its role in synthesis of tryhtophan and is essential in nitrogen metabolism which stimulates growth. These findings are in confirmation with Barman and Pal (1993) in chrysanthemum, Jauhari *et al.* (2005) and Singh and Singh (2004) in gladiolus.

Nath and Biswas (2002) and Kumar *et al.* (2003) recorded linear increase in plant height, number of leaves and leaf area in tuberose and gladiolus, respectively, which might be due to the fact that these nutrients activate several enzymes (catalase, peroxidase, alcohol dehydrogenase, carbonic dehydrogenase, tryptophan synthates, etc.) and involve themselves in chlorophyll synthesis and various physiological activities. Adequate supply of nitrogen and potassium improves the quality of leaves and flowers produce (De-Hertough, 1980). Application of boron increased the number of leaves in dahlia (Khan, 2000) it is due to the increased translocation rate of sugars to different plant parts which is a basic material for the growth of particular organs.

5.1.3 Physiological characters

Application of increased rates of calcium, boron and zinc had a considerable beneficial influence upon the chlorophyll content. Katiyar *et al*. (2005) also supported the similar findings. Ca in the nutrient solution has produced a positive effect on the chlorophyll content (Milivojevic and Stojanovic, 2003).

As far as the leaf nutrient content of tulip is concerned, B, Ca and Zn was recorded higher with higher doses of nutrient application. The increasing trend of calcium might be attributed to limited mobility of the element in phloem (Smith, 1962) and deposition of calcium as calcium pectate in middle lamella and replacement of starch deposits by calcium oxalate crystals which help in sequestering calcium in the leaves. High Ca content in leaves may be attributed to increased Ca content in soil solution.

High Ca concentration in leaves was due to an increase of B in the nutrient solution (Ganmore-Neumann and Davidov, 1993).

Boron has also been reported to increase the mobility of calcium in plants. It was observed that a boron deficiency inhibited Ca translocation (Yamauchi *et al.*, 1986). Leaf boron concentration showed a general increase with increasing levels of calcium, boron and zinc. Increased leaf B in tulip might be due to the increased availability of boron in the soil.

The maximum level of zinc content in leaves may be due to the fact that greater accumulation of zinc occurs at leaf emergence (Smith *et al.*, 1987). Secondly, young growing leaves and regions, where xylem is differentiating actively generally have higher auxin level, which is positively correlated with the zinc concentration.

The results of the present investigation may be compared with the findings of Pratap *et al.* (2004) and Kumar *et al.* (2003) in gladiolus.

5.2 Floral characters

Calcium, boron and zinc have been traditionally employed for improvement in crop production. The chemical fertilizers in soil sustainability and crop productivity has already been emphasized (Tisdal *et al.*, 1985; Katyal, 2000). Result of the present investigations further confirmed that increments in calcium, boron and zinc application caused a significant improvement in floral parameters.

The increase in crop yield and improvement in soil with the application of Ca, B and Zn has been ascribed to the build up in nitrogen assimilation and synthesis of protein and also as a catalytic agent in the activation of enzymes.

The calcium nitrate was effective in induction of flowering in many plant species by sensitizing the buds to floral stimulus (Buschman *et al.* 1980). In the present study, application of boron 1.00 kg ha^{-1} showed early bud initiation and flower opening. Earliness in flowering might be due to optimum boron, favouring storage of carbohydrate and its metabolisum through photosynthesis. The observation is in concurrence with the findings of Singh and Bhattacharjee (1997) in Raktagandha roses and Karthikeyan *et al.* (2009) in carnation.

Khan (2000) reported minimum days taken to first flower bud appearance in dahlia cv**.** Swami Lokeswarananda by foliar application of Zn and B due to the fact that Zn helps in the synthesis of tryptophan and B involved in development of reproductive organs, acting as early flower inducers. Pratap *et al.* (2004)

explained that the promotion of early flower initiation in gladiolus due to micronutrient application is because of their involvement in the synthesis of plant hormones. The beneficial effect of boron has been clearly witnessed through the treatment with 1.00 kg ha^{-1}, which showed increased flower diameter, scape length and thickness. Boron influences the activity of many essential enzymes and this might have lead to increased flower quality. The strongest scapes might be due to the contribution of boron in building up of cell walls. The results obtained are in consonance with the findings of Naik *et al*. (2009) in gladiolus and Karthikeyan *et al.* (2009) in carnation. The earlier reports of Medina (1992) which suggests potassium, calcium and sulphur deficiencies have probable causes for brittle stems and weak flowers lend support to the present findings.

Kumar *et al.* (2003) reported that Zn, Ca and B induced earlier flowering, length of floret, spike length in gladiolus. Zinc recorded the lowest number of days taken to bloom, highest spike length, spike diameter, flower diameter (Kumar, 2001). Zinc might have increased the production of 'Tryptophan' a precursor of IAA which is necessary for healthy plant growth. There was an increased flower diameter with the application of Ca^{2+} in lilium (Salazarorozco, 2010).

Calcium has low mobility in tulips, and there is no translocation from the leaves to the daughter bulbs (Schmalfeld and Carolus, 1965). De-Hertogh *et al.*, (1978) and Nelson (1998) reported that application of $Ca(NO_3)_2$ decreased flower abortion in tulip. Algera (1968) has also shown that there is a localised Ca deficiency in the area of the topple. Stem topple was caused by inhibition of calcium absorption in greenhouse conditions (Lee *et al*., 2001). The internode just below the flower elongate faster than the rest accounting to nearly 43 to 77 per cent of the total post harvest stems elongation (Kelder, 1971). This elongation is shown to be regulated by hormonal balance in the flower stalk.

5.3.1 Bulb characters

Bulbs is the final test to evaluate and justify the contribution of various treatments and their manipulations in the field. The application of nutrients *viz.* calcium, boron and zinc were found to induce striking variations in the bulb yield behaviour in the present study.

Calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) recorded maximum number of bulbs per meter square, highest weight of bulbs and bulblets m^{-2}. This corroborates the findings of several researchers (Katiyar, *et al.*, 2005; Halder *et al.*, 2007). Zinc plays an important role in reproductive biology of plants (Khurana and Chatterjee, 2002). The increase in number and weight of bulbs and bulblets might have been facilitated due to greater mobilisation of photosynthetes to the places where bulbs are formed. Khan (2000) also reported the similar findings in dahlia cv. Swami Lokeswarananda . An application of slow release boron produced remarkable increase in yield of tulip (Le-Nard and DeHertogh, 1993). Highest number of cormels and maximum weight of cormels were obtained with boron-zinc interaction (Halder *et al.*, 2007). This result was supported by Jhon *et al.* (1997). Size of corms and weight of cormels were found significantly increased with boron, calcium and zinc application (Kumar, 2003).

With regard to nitrogen, phosphorus and potassium content of tulip leaves (Table 4.1.1), it was observed that N, P and K content increased with increasing dose of Ca, B and Zn. This was probably as a result of current absorption and also may be due to mobilization of macro-nutrients from source (bulbs) in plant taken up through the roots in gladiolus (Prabhat and Arora, 2000).

5.3.3 Vase life characters

The vase life was expressed as number of days from starting of the experiment until the flowers could no longer be retained as cut flowers.

The days taken to flower opening decreased significantly with the application of Zn, this may be due to the rapid supply of photosynthates to the flowering buds in dahlia (Khan, 2000). De-Hertogh *et al.* (1978) observed that Ca $(NO_3)_2$ improved fresh weight of cut flowers and increased flower size. Weight of cut flowers of oriental hybrid lily was increased with the application of calcium (Choi *et al.*, 2010). The applied nutrients increased dry matter accumulation and moisture contents, thus the weight of flowers might have increased. In present investigation, zinc at 8.00 kg ha^{-1} increased fresh weight of scapes, might be due to the fact that supplementary micronutrients activate several enzymes (catalase, peroxidase etc.) resulting in an enhanced fresh weight of the scapes. The findings are in conformity with reports made by Kumar (2000) and Naik *et al.* (2009) in gladiolus.

Calcium plays an important part in maintaining cell integrity and regulates water uptake (Marschner, 1995; Gilroy *et al.*, 1993). Increase in spike weight was observed by Kumar (2001) in gladiolus with the application of zinc. Boron delayed senescence of petals by directing the translocation of sugar to the corolla and away from the ovary (Aarts, 1957).

The increased scape length and tepal diameter with extended vase life may be attributed to an improved tissue water status and availability of respiratory substrate as these are the prerequisite for normal metabolism and growth (Khan *et al.*, 2007). The diameter of dahlia flowers increased due to the combined effect of Zn and B might be due to the synergistic effect of these two nutrients (Khan, 2000).

5.3.4 Economics

On the basis of pooled flower and bulb yields over two years and cost of cultivation, the data presented in Table 4.5.1 indicated that the net profit and benefit cost ratio remained highest (Rs 7569100 and Rs 1.47, respectively) with treatment combination of $C_2B_2Z_1$, the gross returns were highest (Rs 12719200) with the same treatment combination.

CHAPTER – 6

SUMMARY AND CONCLUSION

The present study entitled "Effect of calcium, boron and zinc on growth, flowering and bulb production of tulip (*Tulipa gesneriana* L.) cv. Apeldoorn" was carried out in two consecutive years 2008-09 and 2009-10 at Research Farm, Division of Floriculture, Medicinal and Aromatic Plants of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar.

Important findings of the study are summarized and conclusions drawn from the experimental results and discussion are given here under :

The soil of the experimental plot was silty clay loam with following characteristics : pH (7.96), electric conductivity (0.54 ds/m), organic carbon (1.09%), available nitrogen (212 kg ha^{-1}), available phosphorus (50 kg ha^{-1}) and available potassium (84.2 kg ha^{-1}). A summarized form of the experimental findings of the study is presented below.

6.1 Effect of Ca, B and Zn on growth and physiological characters

Nutritional management produced a visible impact on the performance of tulip cv. Apeldoorn under Kashmir conditions. This is discernible in the improvement in vegetative, floral and bulb production characters of the crop. While the stature of the plants registered a linear increase from 33.9 to 37.10 cm due to the graded application of calcium, a similar increase was recorded under the influence of boron and zinc, wherein, the tulip plants exhibited a plant height of about 36.03 and 35.47cm with the applications at 1.00 kg ha^{-1} and 8.00 kg ha^{-1}, respectively. Bulb sprouting per cent was, however, not influenced significantly. The foliage parameters also depicted an enhancement. Tulips showed a differential response to the applied nutrients. Among all the nutrients tested, combined effect of calcium, boron and zinc proved superior in vegetative characters, including height of the plants (38.18 cm), number of leaves (5.03

plant^{-1}), wrapper leaf area (179.86 cm^2), leaf calcium content (5.85%), leaf boron content (28.30 ppm) and leaf zinc content (26.96 mg g^{-1}).

6.2 Effect of Ca, B and Zn on floral characters

The interaction of Ca, B and Zn outnumbered even in some important floral attributes like the number of days taken to appearance of floral bud (99.38) as well as days to flower opening (5.00 day), maximum flower diameter (8.96 cm), scape length (25.88 cm), scape thickness (6.84 mm), minimum stem topple (0.00%) and maximum field life (153.37 day).

6.3 Effect of Ca, B and Zn on bulb characters

All the nutrients exhibited a wide variability in bulb characteristics viz. number of bulbs ranging from 46.16 for $C_0B_0Z_0$ to 61.66 for $C_2B_2Z_1$, weight of bulbs ranging from 704.63 in $C_0B_0Z_0$ to 790.00 in $C_2B_2Z_1$; weight of bulblets ranging from 271.80 under $C_0B_0Z_0$ to 417.33 under $C_2B_2Z_1$ and bulb production ratio ranging from 1.15 in $C_0B_0Z_0$ to 1.54 in $C_2B_2Z_1$ treatment combination.

6.4 Effect of Ca, B and Zn on post harvest characters

Vase life attributes in terms of days to flower opening, fresh weight change, water uptake, water loss, water balance, water loss/water uptake ratio, flower diameter, scape length and vase life were significantly altered due to the influence of pre-planting soil applied nutrients (Ca, B and Zn) as compared to untreated control. Among various treatment combinations, calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) i.e; $C_2B_2Z_1$ emerged as most effective level in improving the overall vase life parameters of cut tulip.

6.5 Relative economics

Net returns of various treatments indicated that calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) gave highest net return of Rs. 7569100 with benefit: cost ratio of 1:47, followed by calcium (5.00 kg ha^{-1}), boron (0.50

kg ha^{-1}) and zinc (0.00 kg ha^{-1}) with net return of Rs. 7304900 and B:C ratio of 1.42.

CONCLUSION

In the light of the results obtained on various aspects and available literature it may be concluded that the morphological characteristics exhibited by tulip under the influence of calcium (10.00 kg ha^{-1}), boron (1.00 kg ha^{-1}) and zinc (8.00 kg ha^{-1}) was significantly superior in terms of vegetative, floral and bulb attributes and gave a maximum net return of Rs. 7569100 having a benefit: cost ratio of 1:47 and can be utilized for better growth, flowering and bulb production and getting maximum returns under Kashmir valley conditions.

Therefore nutrient management can go a long way in profitable commercial exploitation of suitable tulip crop. Among the nutrients tested presently, using a combination of calcium, boron and zinc stands out distinctly in important characters and hence can be commercialized in the farmers' fields to boost its performance for quality cut flower and bulb production.

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APPENDIX – I

Meteorological data of 2008-2009 and 2009-2010

Month	Temperature (^{o}C)		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Morning	Evening	
2008					
October	20.81	4.83	84.67	52.54	1.03
November	14.69	0.37	88.89	58.64	2.06
December	12.01	3.00	86.02	59.00	2.08
2009					
January	8.27	-0.03	92.09	70.38	2.76
February	10.42	1.02	87.21	61.50	3.81
March	15.65	3.72	81.93	53.00	1.55
April	19.91	6.93	79.30	51.73	2.71
May	24.94	8.96	74.22	51.12	1.64
June	26.22	11.37	72.53	47.23	2.22
September	28.94	10.19	83.76	47.10	0.90
October	22.71	3.55	86.16	45.12	0.06
November	14.08	0.16	84.23	54.33	1.50
December	13.01	0.12	82.11	50.21	1.10
2010					
January	8.90	1.00	8.30	62.45	3.87
February	10.90	1.02	88.34	63.40	3.92
March	19.88	4.65	83.12	42.03	1.80
April	20.83	6.48	86.46	54.60	3.36
May	25.00	9.02	76.45	52.88	2.03
June	27.30	12.00	75.01	48.33	2.89

[**Source :** Agrometerological Observatory, Division of Agronomy, SKUAST-Kashmir]

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiners Dr. K.P. Singh, Principal Scientist, Directorate of Floricultural Research, IARI Campus, Pusa New Delhi during Viva-Voce examination held on 25-02-2012 have been incorporated in the manuscript entitled **"Effect of calcium, boron and zinc on growth, flowering and bulb production of Tulip (*Tulipa gesneriana* L.) cv. Apeldoorn"** submitted by **Muzamil Rasool (Regd. No. 2007-175-D)**.

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