INFLUENCE OF CALCIUM AND ZINC ON GROWTH AND YIELD OF GREEN CHILLI

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INFLUENCE OF CALCIUM AND ZINC ON GROWTH AND YIELD OF GREEN CHILLI

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This is to certify that the thesis entitled, **"*INFLUENCE OF CALCIUM AND ZINC ON GROWTH AND YIELD OF GREEN CHILLI*"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by ***TOUHID-E-KHUDA*,** Registration No. ***10-03768*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

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TO

MY BELOVED PARENTS

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ABSTRACT

A field experiment was conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, to study the effect of calcium and zinc in green chilli production (cv. BARI Morich 2). The experiment consisted of two factors, *viz.*, Factor A: four levels of calcium (Ca_0: 0 kg ha^{-1}, Ca_1: 19 kg ha^{-1}, Ca_2: 27 kg ha^{-1} and Ca_3: 35 kg ha^{-1}) and Factor B: three levels of zinc (Zn_0: 0 kg ha^{-1}, Zn_1: 2.5 kg ha^{-1} and Zn_2: 5.0 kg ha^{-1}).Vegetative growth, yield Contributing characters and yield were measured during the experiment. In case of calcium, the highest number of flowers $plant^{-1}$ (69.65), number of fruits $plant^{-1}$ (59.63), average fruit weight (2.66 g), fruit yield $plant^{-1}$ (243.60 g) and fruit yield ha^{-1} (10.30 t) were recorded in treatment of Ca_2 (27 kg ha^{-1}), meanwhile, the lowest values of the above mentioned parameters were found in the control. On the other hand, in case of zinc, the highest number of flowers $plant^{-1}$ (71.90), number of fruits $plant^{-1}$ (62.18), average fruit weight (2.84 g), fruit yield $plant^{-1}$ (257.10 g) and fruit yield ha^{-1} (10.90 t) were recorded in treatment of Zn_1 (2.5 kg ha^{-1}), meanwhile, the lowest values of the above mentioned parameters were found in the control. In case of interaction effect, the highest values of the above mentioned parameters were found in Ca_2Zn_1. The highest Benefit Cost Ratio (3.69) was also found from Ca_2Zn_1 treatment combination. Therefore it can be concluded that 27 kg ha^{-1} of calcium and 3.5 kg ha^{-1} of zinc were found beneficial for growth and yield of green chili.

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LIST OF ABBREVIATED TERMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
i.e.	=	that is
LSD	=	Least Significant Difference
m^2	=	Meter squares
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
Zn	=	Zinc
µg	=	Microgram
TSP	=	Triple Super Phosphate
MoP	=	Muriate of Potash

CHAPTER I

INTRODUCTION

Chilies (*Capsicum annuum* L.) belong to the nightshade family, Solanaceae and originated from South America; the name comes from Nahuat via the Spanish word chili (Wikipedia, 2006).

Chilies are very rich in vitamin C and pro-vitamin A, particularly the red chilies. Yellow and especially green chilies (which are essentially unripe fruit) contain a considerably lower amount of both substances. In addition, peppers are a good source of most B vitamins, and vitamin B6 in particular. They are very high in potassium and high in magnesium and iron. Their high vitamin C content can also substantially increase the uptake of non-heme iron frother ingredients in a meal, such as beans and grains. Chemical analysis of chilli have shown that red chilli fruit contains 15.9% protein, 31.6% carbohydrate, 50 mg/100g vitamin-C and small quantities of vitamin A, B and E (Sparkyby, 2006).

Chilli is the most essential and important spice crop in Bangladesh. It is an indispensable spice, which is liked for pungency and spicy taste and the appealing color adds to the curry. The production of chilli largely depends on the use of fertilizers, irrigation, pesticide etc. The Government of Bangladesh has, therefore, provided priority to the agriculture sector to increase the production of vegetable, including chilli, by giving subsidy to the farmers. Chilli occupies about 227000 acres with a production of 123000 tons (BBS, 2016). It is also a cash crop of the country (Ahmed and Haque, 1980). It is cultivated on small family-owned farms where sale of its produce as a ready source of cash income throughout the year. A large number of cultivars or landraces are under cultivation in different parts of the country.

Macro and micronutrients play a vital role in the physiology of plants. Among the secondary nutrients and micronutrients, calcium (Ca), zinc (Zn) played a major role in the chilli production.

Calcium plays a key role in plant growth and fruit development and it is involved in many biochemical and physiological processes (Saure, 2005). Pepper plants responded positively to foliar application of nutrients (Padem *et al*., 1999). Also pepper yield can be improved by foliar application of calcium (Lin *et al*., 2000).Calcium moves readily from roots to leaves. However, unlike other elements, it is very poorly redistributed from leaves to other plants parts (Guttridge and Bradfield, 1983). Thus, bulky storage tissues or young leaves are likely to be susceptible to localized Ca deficiency induced by poor mobility. Clover (1991) reported that short distance transport of Ca in the fruit is also very important and has indicated that this declines as distance from the pedicle increases making them susceptible to the disorder.

Zinc (Zn) also played a vital role for successful green chilli production. Singh et al. (1989) observed that higher plant height with soil application of zinc sulphate as well as foliar spray. Application of zinc at the rate of 3 ppm noticed maximum number of leaves and number of roots per plant (Sindhu and Tiwari, 1989) and soil plus foliar application of zinc sulphate each at 20 kg/ha and 0.5% respectively produced maximum number of branches per plant (7.52) (Singh et al., 1989) where application of $ZnSO_4.7H_2O$ received by chilli at 20 kg per ha enriched with vermicompost recorded the highest yield (Patil *et al*., 2011). One of the reasons of lower yield might be imbalanced use of fertilizers and manure and low levels of available Zn in the soils of major chilli growing areas (Bose and Tripathi, 1996).

Considering the above fact the study was undertaken on following objectives:

i. to investigate the effect of calcium and Zinc on growth and yield of green chilli and
ii. to find out the suitable combination of calcium and zinc for higher yield of green chilli.

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of calcium (Ca)

Halina *et al*. (2016) conducted an experiment to evaluate the effects of foliar Ca feeding on the yield of chilli 'Caryca F1' and on selected elements of its fruit quality in field ground cultivation. Calcium is one of the basic nutrients of plants, crucial in many cell processes. Calcium in a plant is reutilized very poorly, and hence symptoms of deficiency of this component are observed on the youngest leaves, apexes of stems and roots, and, most importantly, on the fruits. Ca was applied in the form of the following preparations: $Ca(NO_3)_2$, Insol Ca, or Librel Ca. Calcium preparations were applied on 3 or 5 dates in 1% concentration of the solution to the full wetting of the plants. A positive influence of Ca feeding on the marketable yield of the fruit was observed: 4.26–4.63 kg m^{-2} as compared with the controls at 3.80 kg m^{-2}. Calcium foliar feeding caused a limited number of fruits. The use of $Ca(NO_3)_2$ had a positive effect on the accumulation of vitamin C and carotenoids as compared with other fertilizers. Reduced Ca spraying proved to be beneficial in terms of fruit yield and concentrations of carotenoids.

Rubio *et al*. (2010) investigated the influence of Ca^{2+} and K^+ levels on fruit yield and quality of chilli plants. The treatments consisted of three concentrations of Ca^{2+}(1.5, 4 and 8 mmol L^{-1}) and K^+ (2.5, 7 and 12 mmol L^{-1}) that were imposed separately. Fruit yield parameters and different fruit quality parameters, as well as dry matter production and mineral composition in individual parts of the plant, were determined. The increase of Ca^{2+} in the root medium increased the marketable yield from 1.67 to 2.38 kg $plant^{-1}$, mainly due to an increase in the number of fruits per plant. With respect to fruit quality, fruit shape index and, therefore, pepper fruit appearance improved with Ca^{2+} addition to the root medium. Low Ca^{2+} or high K^+ levels reduced both root and shoot dry matter.

Therefore, an adequate management of fertilization with Ca^{2+} and K^{+} could improve the yield and fruit quality of chilli.

El-Tohamy *et al*. (2006) conducted an experiment to improve the productivity of chilli plants grown under unheated greenhouse conditions by foliar application of nutrients. Different nutrient treatments were applied including two levels of each of superphosphate, calcium chloride and potassium chloride while control plants were not treated. The results showed that all fertilization treatments significantly improved chilli growth parameters (plant height, number of branches, number of leaves and fresh weight of plants) and yield compared to control plants especially at the higher levels. The results indicated that additional foliar application of nutrients especially by phosphorus, calcium and potassium can improve growth and yield of chilli plants grown under sandy soil conditions during winter season.

A field experiment was carried out by Shivaprasad *et al*. (2009) to study the effect of secondary and micronutrients on yield and quality of chilli cv. Bydagi. The Recommended doses of inorganic NPK Fertilizers (RDF) at 100:50:50 kg/ha was applied along with various doses of secondary and micronutrients (Ca at 25 and 50, S at 25 and 50, Fe at 10 and 20 kg/ha). The pooled results revealed that RDF+Ca+S+Fe at 50+50+20 kg/ha recorded significantly higher chilli yield (1189 kg/ha) compared to the rest of the treatments, except for RDF+Ca+S at 50+50 kg/ha (1119 kg/ha) and RDF+Ca+S+Fe at 25+25+10 kg/ha (1176 kg/ha). Significantly higher benefit:cost ratio (2.56) was recorded with RDF+Ca+S+Fe at 25+25+10 kg/ha compared to the rest of the treatments. However, it was on par with RDF+Ca+S+Fe at 50+50+20 kg/ha and RDF+Ca+S at 50+50 kg/ha (2.45 and 2.29, respectively).

Guzman and Sanchez (2003) conducted an experiment to regulate the growth rate of chilli seedling by controlling the concentration of N and Ca in the growing medium. Transplant quality parameters and early yield production of chilli plants may be modified by the composition of nutrient solution both in nursery and in initial greenhouse stages. Levels of NO_3^- and Ca^{2+} exceeding normal concentration resulted in decreased seedling growth, shorter internodes, lower shoot/root relations, and higher SLA. These effects are presumably due to the increase in solution salinity and the greater osmotic potential in the growing medium. An adequate balance between growth rates and transplant quality parameters was obtained with 8 $meq \cdot L^{-1}$. NO_3^- and 5 $meq \cdot L^{-1}$ Ca^{2+} in nursery fertigation solution. When different cultivars of transplanted chilli were subjected to very high concentrations of NO_3^- (32 $meq \cdot L^{-1}$) and low concentrations of Ca^{2+} (5 $meq \cdot L^{-1}$) in nutrient solution, the vegetative growth rate, leaf area expansion parameters and leaf biomass production were positively affected. The effect of these concentrations on reproductive growth stages varied among the different cultivars, but overall the number of early fruit was negatively affected.

Good bio-availibility of calcium can be achieved by calcisation, but in many cases owing to its high prices, long-term effects, along with a delayed initial effect, as well as problems that appear due to radical change in availability of other nutrients in soil, its application is restricted (Vukadinović and Lončarić, 1998). However, growth on substrates with high concentrations of NH_4^+, K^+ and Mg^{2+} may result in insufficient absorption of calcium (Kastori, 1983).

Calcium, an essential macronutrient, plays a decisive role in the maintenance of cell membrane integrity (Morard *et al.*, 1996) and membrane permeability; enhancing pollen germination and growth; activating a number of enzymes for cell mitosis, division, and elongation; possibly detoxifying the presence of heavy metals in tissue; affecting fruit quality, and health of conductive tissue (Jones, 1999). Calcium is also involved in numerous cellular functions that are regulated in plant cells by changes in cytosolic Ca^{2+} concentrations, such as ionic balance, gene expression, and carbohydrate metabolism (Bush, 1995).

The Ca content in higher plants is generally about 0.5 % on a dry matter basis. These high Ca concentrations are a result of high Ca^{2+} levels in the soil solution rather than from the efficiency of Ca^{2+} uptake by root cells. Generally the Ca^{2+} concentration of the soil is about 10 times higher than that of K^+ whereas the uptake rate of Ca^{2+} is usually lower than that of K^+ (Clarkson and Sanderson, 1978). Its uptake can also be competitively depressed by the presence of other cations such as K^+ and NH^{4+}, since roots usually take these up more rapidly than Ca^{2+} (Mengel and Kirkby, 2001).

Calcium is mainly translocated in the xylem sap and only poorly in the phloem. Marschner (1995) assumed that the extremely low levels of Ca^{2+} in the phloem sap are a consequence of Ca accumulation in the cells surrounding the phloem. As a result of low Ca^{2+} in the phloem, all plant organs, which are largely provided with nutrients by the phloem sap, are relatively low in Ca (Mengel and Kirkby, 2001). Ca transport to the fruit may also be reduced by development of more foliage that may compete with the fruit for water, particularly under periods of low relative humidity (Nonami *et al*., 1995).

The poor supply of Ca^{2+} to fruits and storage organs can result in Ca deficiency in these tissues (Mengel and Kirkby, 2001). Calcium deficiency brings about the appearance of visual symptoms with the blackening and the peripheral deformation of the blade of the younger leaves and decline in growth of merismatic tissue (Morard *et al*., 1996). The deficiency can first be observed in the growing tips and youngest leaves that become deformed and chlorotic and in more advanced stages, necrosis occurs at the leaf margins (Mengel and Kirkby, 2001).

Plant Ca deficiencies are frequently restricted to low transpiring, fast growing tissues such as shoot apex, fruits, and storage organs. Calcium deficiency may lead to early senescence and absence of fructification. Seeds that are deficient in Ca generally have poor germination and produce abnormal, weak seedlings, even when seed are germinated in a complete and balanced nutrient containing media (Taylor and Locascio, 2004). Since most mineral soils are rich in available Ca, deficiency occurs infrequently in plants but an undersupply of Ca to fruit and storage tissues may occur (Mengel and Kirkby, 2001). Ca deficiency is most often due to decreased calcium uptake and transport within the plant as a result of water supply disturbances or excess salinity (Adams and Ho, 1993) rather than the lack of calcium in the nutrient solution (Morard *et al*., 1996).

Calcium is one of the most important mineral nutrients in greenhouse production (Hao and Papadopoulos, 2003) since it has an important function in the integrity and stability of the cell membrane (Marschner, 1995). Calcium movement, in the plant, is restricted to the xylem, causing fruit to have less than 2 of the total calcium in the plant (Ehret and Ho, 1986). The calcium concentration in distal fruit of a cluster tends to be lower than in proximal fruit (Petersen *et al*., 1998), indicating a higher probability of physiological disorders, associated with Ca, to develop in distal than proximal fruit on the same truss (Dorais *et al*., 2001).

An adequate supply of Ca to the fruit is essential for firmness and shelf life. Increased Ca levels in the nutrient solution increase calcium levels in the fruit, but decrease capsicin content and antioxidant levels in the chilli fruits (Paiva *et al*., 1998b) and negatively affect their organoleptic quality (De Kreij, 1995). Fruit firmness can be improved by spraying calcium salts (Cooper and Bangerth, 1976) while fruit maturing can be delayed by increasing calcium content of the fruit from 0.11 $mg.g^{-1}$fresh weight to 40 $mg.g^{-1}$ (Wills *et al*., 1977). Insufficient Ca supply will increase the number of fruits affected by BER and may stimulate ethylene synthesis (Bangerth, 1979) and consequently the biosynthesis of carotenoids (Kays, 1991), which are responsible of chilli fruit colour (Dorais *et.al*., 2001). Calcium deficiencies reduce leaf size; cause necrosis of young leaves and in extreme cases yields loss (Hao and Papadopoulos, 2003).

According to Hao and Papadopoulos (2003), high Ca concentrations (7.5 mM) in the nutrient solution allow for higher total yields, higher marketable fruit yields, larger fruits, and higher percentages of marketable fruit compared to low Ca concentrations (3.5 mm). For maximum plant growth, Bryson and Barker (2002) suggested that nutrient solutions should be 5 mm Ca. Bar-Tal and Pressman (1996) observed increased marketable yields with increased Ca levels due to a reduction in Blossom End Rot incidence.

2.2 Effect of zinc (Zn)

Jamre *et al.*(2010) highlighted the effect of different levels of sulphur and zinc on growth of cauliflower at College of Agriculture, Gwalior (M.P.) Maximum plant height (57.25 cm), plant spread (1918.02 cm^2) and dry matter yield (10.60) were recorded due to soil application of zinc sulphate at 6 kg ha^{-1} compared to control. Similarly, Rohidas *et al*. (2010) conducted an experiment on the effect of micronutrients on yield of chilli at Marathwada Agriculture University.

Baloch *et al*. (2008) conducted a study with commercial foliar fertilizer, HiGrow is a composition of various macro and micronutrients was applied on chilies at the concentrations 4, 5, 6, 7 and 8 ml/L water in addition to soil applied NPK fertilizers at 50-50-25 kg ha^{-1} to investigate their associative effect on production of green chilies. HiGrow at 8 ml/L water resulted 68 cm plant height, 6.93 branches $plant^{-1}$, 118.86 fruits $plant^{-1}$, 4.19 cm fruit length, 395 g fresh chilies fruit weight $plant^{-1}$ and 14977 kg fresh chilies yield ha^{-1}; while decreasing concentration to 7 ml/L water produced 67.86 cm plant height, 6.53 branches $plant^{-1}$, 117.20 fruits $plant^{-1}$, 4.14 cm fruit length, 391.33 g fresh chilies weight $plant^{-1}$ and 14562.33 kg fresh chilies yield ha^{-1}. HiGrow at 6 ml/L water formed 66.46 cm plant height, 5.80 branches $plant^{-1}$, 112.36 fruits $plant^{-1}$, 3.89 cm fruit length, 351.66 g fresh chilies weight $plant^{-1}$ and 12696.33 kg fresh chilies yield ha^{-1}.

Singh *et al*. (1989) conducted an experiment at N. D. University of Agriculture and Technology, Faizabad (U.P.) to study the growth and yield of chilli in relation to zinc levels. Results showed higher plant height (40.47 cm) with soil application of zinc sulphate as well as foliar spray (20 kg ZnSO4 + 0.5% foliar spray).

Sindhu and Tiwari (1989) conducted an experiment to study the effect of micronutrients on chilli (CV. Pusa Red) at G.B. Pant University of Agriculture and Technology, Pantnagar (Uttaranchal). Result revealed that, application of zinc @ 3 ppm noticed maximum number of leaves and number of roots per plant. Similarly, an experiment was conducted by Singh *et al*. (1989) at N. D. University of Agriculture and Technology, Faizabad (U.P.) to study the growth and yield of chilli in relation to zinc levels. Results showed that, soil + foliar application of zinc sulphate each at 20 kg/ha and 0.5% respectively produced maximum number of branches per plant (7.52).

Patil *et al*. (2011) reported the effect of zinc and iron levels on yield of chilli at AICRP, Belvatagi, UAS, Dharwad (Karnataka). Results showed that, chilli crop receiving application of $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$ each at 20 kg per ha enriched with vermicompost recorded the highest yield (1.85) tonnes per ha.

Das (2007) highlighted the importance of zinc in maintaining the integrity of biomembrane viz., pericarp in chillies. It may bind to phospholipid and sulphydryl groups of pericarp component of red chillies to form tetrahedral complexes. Zinc may further protect membrane lipid and proteins against oxidative damage.

Swati Barche *et al*. (2011) conducted an experiment on the effect of foliar application of micronutrients on chilli (Cv Rashmi) at College of Agriculture, JNKVV, (M. P.). Results revealed that maximum plant height (80.40 cm), number of branches (34.43) and number of flowers (41.47) per plant were recorded with the application of Boric acid + $ZnSO_4$ + $CuSO_4$ each at 250 ppm. Similarly Yadav *et al*. (2001) studied the effect of zinc sulphate application on growth of Chilli

(Cv. Jaffa) at CCS Agricultural University, Hissar (Haryana). Results showed significant increase in plant height (10.71) and plant spread (10.78 cm) with the application of zinc sulphate @ 250 g/plant. Minimum values of plant height (8.11cm) and plant spread (7.40 cm) were recorded under control.

Satyapal Singh and Prabhakar Singh (2004) conducted an experiment to know the effect of foliar application of nitrogen and zinc on yield of Chilli at College of Agriculture, Jobner (Rajasthan).

Mahesh Kumar and Sen (2005) conducted an experiment to study the effect of zinc, boron and gibberallic acid on the yield of Chilli at Rajasthan College of Agriculture, Udaipur (Rajasthan). Results revealed that, application of zinc upto 30 kg/ ha as $ZnSO_4$ significantly improved the number of fruits per plant (13.34), fruit length (16.82 cm), fruit weight (16.58 g), yield per plant (218.55g) as well as yield/ha (147.20 q/ha).

Halder *et al*. (2007) conducted an experiment to study the effect of soil application of zinc sulphate on yield of ginger at Agriculture Research Institute, Joydebpur, Bangladesh. Results showed that, maximum number of primary fingers (4.5), secondary fingers (5.6) and tertiary fingers (4.0) were due to application of $ZnSO_4$ at 4.5 kg /ha. Similarly weight of fingers (209 g), weight of fingers per plant (261 g) and weight of corm (36.3 g) were observed due to application of 4.5 kg /ha of zinc sulphate.

Giridhar Kalidasu *et al*. (2008) reported the influence of micronutrients on yield and yield attributing characters of coriander under rainfed conditions ANGRAU, Hyderabad (A.P.). Results revealed, maximum number of umbels per plant (27.4), number of umbellets per umbel (6.4) and yield per ha (940 kg) in treatment that received combined application of $ZnSO_4$ + $FeSO_4$ + $CuSO_4$ + $MnSO_4$ each at 0.5 per cent concentration.

An experiment was conducted to study the effect of different levels of sulphur and zinc on growth of cauliflower at College of Agriculture, Gwalior (M.P.). Results revealed that, highest fresh weight of curd per plant (0.851 kg/plant) and yield of curd per ha (317.57 q/ha) were recorded due to soil application of zinc sulphate at the rate of 6 kg per hectare (Jamre *et al*. 2010).

Rohidas *et al*. (2010) reported the effect of micronutrients on yield of garlic at Marathwada Agriculture University, Parbhani (Maharashtra). Maximum fresh weight of bulbs(35.55 g), cured weight of bulbs (33.15 g), weight of clove (2.65 g) and bulb yield per ha (155.39 q/ha) were recorded due to foliar application of zinc sulphate at 4 ppm.

Patil *et al*. (2010) conducted an experiment to study the effect of foliar application of micronutrients on yield of tomato (CV. Phule Raja) at College of Agriculture, Latur, Parbhani (Maharashtra). Results revealed that, application of Fe + Zn each at 100 ppm along with boron at 50 ppm significantly increased the total number of fruits (23.88) and number of marketable fruits/plant (20.34).

Swati barche *et al*. (2011) conducted an experiment to know the effect of foliar application of micronutrients on tomato (Cv Rashmi) at College of Agriculture, JNKVV, Jabalpur, (M. P). Application of Boric acid + $ZnSO_4$ + $CuSO_4$ each at 250 ppm influenced the fruit yield per plant (1.18 kg) as well as fruit yield per hectare (375.94 q/ha).

Shil *et al*. (2013) conducted a field trial on chilli (cv. Bogra local) in Grey Terrace Soil under AEZ-25 (Level Barind Tract) at Spice Research Centre. The objectives were to evaluate the response of chilli to zinc to find out the optimum dose of zinc for maximizing the yield. Treatments for this study comprised of four levels each of zinc (0, 1.5, 3.0, and 4.5 kg/ha) along with a blanket dose of N130 P60 K80 S20 Mg10 kg/ha. The effect of zinc was significant in case of yield of dry chilli and weight of ripe chilli/plant. However, from regression analysis, the optimum-economic dose of zinc was found to be 3.91 kg/ha. Hence, a package of (Zn 3.91 kg/ha) along with the said blanket dose may be recommended for maximizing the yield of chili in the study area.

Three micronutrients (Zn, Fe, B) were tried in three concentrations i.e. 0.1, 0.25 and 0.50% foliar spray in a field experiment conducted by Dongre *et al*. (2000). There were ten treatments replicated three times and applied at 30 and 60 days after transplanting. The observation on fruit yield per plant and quality of chili fruits per plant were recorded and analysed statistically. The treatment T_3 ($ZnSO_4$ 0.50%) exhibited the maximum yield (111.75 q/ha) and treatment T5 ($FeSO_4$ 0.25%) produced the maximum number of seeds/fruit (57.93).

The study was conducted with a pot experiment by Datir *et al*. (2012) to determine the effects of foliar application of organically chelated micronutrients on growth and yield in chili (*Capsicum annum* L.). The micronutrients like iron, zink, copper and manganese were organically chelated with seed amino acids. Forty day's old seedlings of chili were transplanted in the pots. The experimental plants were sprayed with three doses (0.5, 1.5 and 2.0%) of organically chelated micronutrients along with unchelated micronutrients, amino acid solution and untreated control plants on 15^{th} and 30^{th} days after transplantation. The results based on two years mean revealed that out of five different treatments, the application of amino acid-micronutrient chelate at the concentration of 1.5 and 2.0% resulted in maximum plant height, number of primary branches, higher leaf area per plant, fruits per plant and more total yield per plant.

Yogananda *et al*. (2004) conducted an experiment with ten grams seeds of bell pepper [Capsicum annuum] (cv. California Wonder) were soaked in 150 ml solution each of gibberellic acid (GA_3) at 100 (T_1), 150 (T_2) and 200 ppm (T_3); T_1 + cytokinin at 100 ppm (T_4), T_2 + cytokinin at 50 ppm (T_5), T_3 + cytokinin at 50 ppm (T_6), NAA at 40 ppm (T_7), Miraculon at 200 (T_8), 450 (T_9) and 750 ppm

(T_{10}), $CuSO_4$ at 0.2% (T_{11}), $ZnSO_4$ at 0.2% (T_{12}), Borax at 0.4% (T_{13}), $MgSO_4$ at 0.2% (T_{14}), KNO_3 at 0.5% (T_{15}) and 1.0% (T_{16}) for 24 hour and dried back to original weight. A control (T_0) was included. Significantly higher germination (91.05%) was obtained with T_3 compared with other concentrations of GA_3, combination of GA_3 + cytokinin treatments and T_7. However, these treatments recorded higher germination over T0 (81.5%). Significantly longer root (5.55 cm) and shoot (7.50 cm), higher germination rate (12.75), seedling dry weight (53.5 mg) and seedling vigour index (1174) were obtained from seeds invigourated with T3 compared to the control (4.27 cm, 5.75 cm, 9.04, 42.25 mg and 518, respectively). Seeds invigourated with the micronutrients significantly increased the seed germination. Among the micronutrients, T_{15} recorded significantly higher germination (89.75%) over the control. T_{11}, T_{12}, T_{13} and T_{14} also recorded significantly higher germination, root length, shoot length, seedling dry weight, germination rate and seedling vigour index over the control.

Salam *et al*. (2011) carried out an experiment to investigate the effect of boron, zinc, and cowdung on quality of tomato. There were 16 treatments comprising four rates of boron and zinc viz., BoZno. $B_{1.5}Zn_2$ B_2Zn_4 and B2.5Zn6 kg/ha and four rates of cowdung viz., CDo, CD10, CD15, and CD20 t/ha. Every plot received 253 kg N, 90 kg P, 125 kg K, and 6.6 kg S per hectare. The results reflected that the highest pulp weight (90.24%), dry matter content (5.82%), ascorbic acid (11.2 mg/100g). lycopene content (147 µg/100g), chlorophyll-a (42.0 µg/l00g), chlorophyll-b (61.0 µg/100g), boron content (36 µg/g), zinc content (51 µg /g), marketable fruits at 30 days after storage (74%) and shelf life (17 days) were recorded with the combination of 2.5 kg B/ha + 6 kg Zn/ha, and 20 t/ha cowdung.

From the above review of literature it is revealed that Ca and Zn had significant effect on growth, yield contributing characters and yield of green chilli.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from November 2015 to March 2016 to study the influence of calcium and zinc levels on growth and yield of green chilli. This chapter includes a brief description of the methods and materials that were used for conducting the experiment.

3.1 Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment was carried out during rabi season. The location of the study was situated in 23°74′ N latitude and 90°35′ E longitude (Anon., 1989). The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

3.2 Climatic condition

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.3 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics are presented in Appendix II.

3.4 Plant material

Chilli (cv. BARI Morich 2) was used as experimental material. The seeds were collected from Siddique bazar, Dhaka-1000.

3.5 Treatments

The experiment consisted of two factors:

Factor A: Calcium* – Four levels of calcium denoted as Ca

1. Ca_0 = 0 kg ha^{-1} (0 g $plot^{-1}$)
2. Ca_1 = 19 kg ha^{-1} (5.4 g $plot^{-1}$)
3. Ca_2 = 27 kg ha^{-1} (8.1 g $plot^{-1}$)
4. Ca_3 = 35 kg ha^{-1} (10.5 g $plot^{-1}$)

   * Gypsum was used as source of calcium.

Factor B: Zinc** – Three levels of zinc denoted as Zn

1. Zn_0 = 0 kg ha^{-1} (0 g $plot^{-1}$)
2. Zn_1 = 2.5 kg ha^{-1} (1.05 g $plot^{-1}$)
3. Zn_2 = 5.0 kg ha^{-1} (1.50 g $plot^{-1}$)

   ** Zinc Oxide (ZnO) was used as source of zinc.

Treatment Combinations of Ca and Zn – 12 (4 × 3) treatment combinations such as Ca_0Zn_0, Ca_0Zn_1, Ca_0Zn_2, Ca_1Zn_0, Ca_1Zn_1, Ca_1Zn_2, Ca_2Zn_0, Ca_2Zn_1, Ca_2Zn_2, Ca_3Zn_0, Ca_3Zn_1, Ca_3Zn_2.

3.6 Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 25m×8m = 200 m^2 which was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random.

There were 36 unit plots altogether in the experiment. The size of the each plot was 2.0 m × 1.5 m. The distance maintained between two blocks and two plots were 0.5 m, respectively. Seeds were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 30 cm, respectively. The layout of the experiment is shown in Figure 1.

3.7 Seedbed preparation

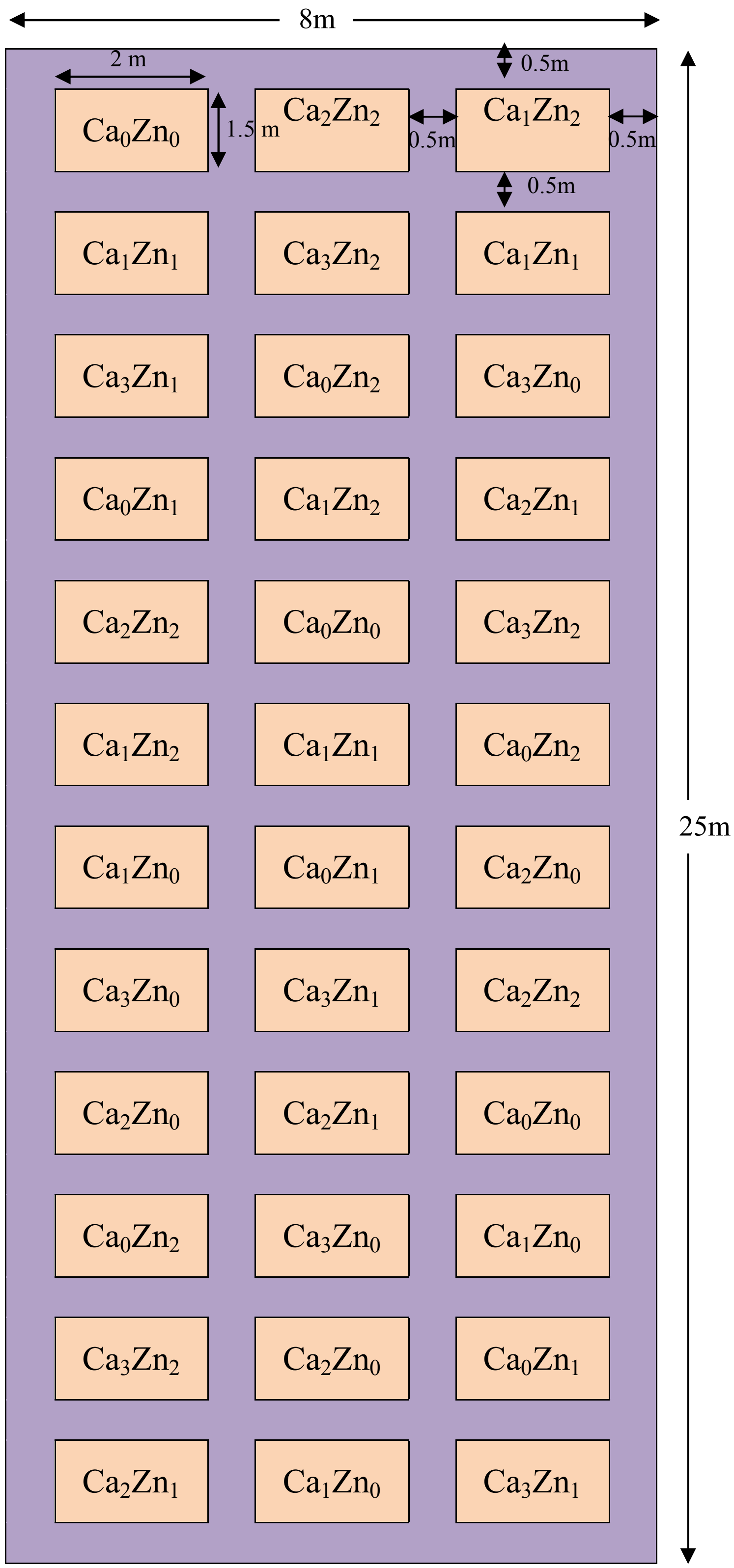
Seedbed was prepared on 6th November 2015 for raising seedlings of green chilli and the size of the seedbed was 3 m × 1 m. For making seedbed, the soil was well ploughed. Weeds, stubbles and dead roots were removed from the seedbed. Cowdung was applied to the prepared seedbed @ 10 t/ha. The soil was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworms. Seeds were treated by Vitavex-200 @ 5 g/1kg seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc.

3.8 Seed sowing

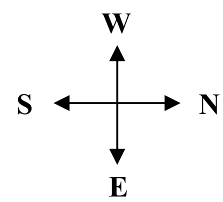
Seeds were sown on 12th November 2015 in the seedbed. Sowing was done in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by watering can. Thereafter, the beds were covered with polythene to maintain required temperature and moisture.

3.9 Raising of seedlings

Light watering and weeding were done several times as per needed. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 30 days old seedlings were transplanted into the experimental field on 11 December 2015.



LEGEND



Layout:

Plot size: 2.0 m × 1.5 m

Plot spacing: 0.5 m

Between block: 0.5 m

Treatments:

Factor A: Calcium (Ca)

1. Ca_0 = 0 kg Ca ha^{-1}
2. Ca_1 = 19 kg Ca ha^{-1}
3. Ca_2 = 27 kg Ca ha^{-1}
4. Ca_3 = 35 kg Ca ha^{-1}

Factor B: Zinc (Zn)

1. Zn_0 = 0 kg Zn ha^{-1}
2. Zn_1 = 2.5 kg Zn ha^{-1}
3. Zn_2 =5.0 kg Zn ha^{-1}

Fig.1. Layout of the experimental plot

3.10 Preparation of the field

The plot selected for conducting the experiment was opened in the first week of December 2015, with a power tiller and left exposed to the sun for a week to kill soil borne pathogens and soil inhabitant insects. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. Weeds, crop residues and stables were removed from the field. The basal dose of manure and fertilizers were applied at the finally ploughing. The plots were prepared according to design and layout of the experiment. The soil of the plot was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworm.

3.11 Application of manure and fertilizers

The fertilizers N, P, K and S in the form of urea, TSP, MoP and gypsum, respectively were applied (BARI, 2011). Half of the quantity of cowdung was applied during final land preparation. The remaining half of cowdung, the entire amount of TSP, gypsum and one third of urea and MoP were applied during pit preparation. Urea and MoP were applied in two equal installments at before flowering and fruit setting. Calcium and zinc were applied as per treatment. The dose and method of application of fertilizer are shown in Table 1.

Table 1. Doses and method of application of fertilizers in green chilli field

Manure and Fertilizers	Amount (ha)	Application (%)			
		Final land preparation	Installments		
			Pit preparation	Before flowering	Fruiting stage
Cowdung	10 ton	50.00	50.00	--	--
Urea	250 kg	--	33.33	33.33	33.33
TSP	330 kg	--	100.00	--	--
MoP	250 kg	--	33.33	33.33	33.33
Ca	As per treatment				
Zn	As per treatment				

Source: Fertilizer Recommendation Guide.2012

3.12 Transplanting

Healthy and uniform 30 days old chilli seedlings were transplanted in the experimental plots on 11 December, 2015. The seedlings were uprooted carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 40 cm, respectively and total 12 plants were accommodated in each plot. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border of the experimental plots for gap filling.

3.13 Intercultural operation

After raising seedlings, various intercultural operations, such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the chilli seedlings.

3.13.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Planted earlier on the border of the experimental plots same as planting time treatment. Those seedlings were transplanted with a big mass of soil with roots to minimize transplanting stock. Replacement was done with healthy seedling having a boll of earth. The transplants were given shading and watering for 7 days for their proper establishment.

3.13.2Application of Ca and Zn

Micronutrients were applied as per treatment. For each treatment 100 ppm were sprayed on the foliage of the plants during vegetative stage, flower initiation stage and 2 times at blooming by a mini hand sprayer.

3.13.3 Weeding

The hand weeding was done 15, 30 and 45, 60 after transplanting to keep the plots free from weeds.

3.13.4 Earthing up

Earthing up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.13.5 Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings.

3.13.6 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seeding in the field. In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some of plants were infected by Alternaria leaf spot diseases caused by Alternaria brassicae. To prevent the spread of the disease Rovral @ 2 gm per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field.

3.14 Harvesting

Harvesting of fruits was started at 80 DAT and continued up to final harvest based on the marketable sized of fruits. Harvesting was done by hand picking.

3.15 Data collection

Three plants were randomly selected for data collection from the middle rows of each unit plot for avoiding border effect, except yields of fruits, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth, yield attributes and yields.

3.15.1 Plant height

Plant Height was measured from sample plants in centimeter from the ground level to the tip of the longest stem and mean value was calculated. Plant height was also recorded starting from 20 days after transplanting (DAT) up to harvest at 20 days interval.

3.15.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 selected tagged plants at random from the inner rows of each plot from 20 DAT to fruit harvest at 20 days interval.

3.15.3 Number of branches per plant

The number of branches per plant was manually counted at 40 days after transplanting from tagged plants. The average of five plants were computed and expressed in average number of branch per plant.

3.15.4 Total dry mass plant^{-1} (g)

The dry weight of plants was recorded in gram. Data was recorded after harvest with fruit yield of selected tagged plant. Five plants were uprooted with the help of nirani (hand hoe) and cleaned with water; plants were over dried at 80^0C until a constant weight was obtained.

3.15.5 Stem base diameter of plant

The stem base diameter of plant was manually counted at harvest from tagged plants. The average of five plants were computed and expressed in average stem base diameter of plant.

3.15.6 Days to flower initiation

The number of days from the date of transplanting to the date of first flower opening was recorded.

3.15.7 Number of flowers per plant

The number of flowers per plant was counted at 50 DAT to at harvest from the 5 sample plants. The final average value of number of flowers was calculated from 5 averages from five plants.

3.15.8 Days to first fruiting

The number of days from the date of transplanting to the date of first fruit bearing was recorded.

3.15.9 Number of total fruits/plant

The number of total fruits per plant was counted after setting of fruits and recorded per plant basis.

3.15.10 Length of fruit

The length of fruit was measured with a meter scale from the neck of the fruit to the bottom of 10 randomly selected marketable fruits from each plot and there average was taken and expressed in cm.

3.15.11 Diameter of fruit

Diameter of fruit was measured at the middle portion of 10 randomly selected marketable fruit from each plot with a digital calipers-515 (DC-515) and average was taken and expressed in cm.

3.15.12 Number of seeds per fruit

Seeds were separated from randomly selected10 fruits and average number of seeds was calculated.

3.15.13 Individual fruit weight

The weight of individual fruit was measured with a digital weighing machine from 10 randomly selected marketable fruits from each unit plots and there average was taken and expressed in gram.

3.15.14 Weight of 1000 seeds

Fresh weights of dried seeds were measured at the 60 days after transplantation from the 5 selected plants and there average was taken.

3.15.15 Fruit yield per plant

Average fruit weight per plant was measured by using the following formula-

$$\text{Average fruit weight per plant} = \frac{\text{Yield of fruit/plot}}{\text{Number of plant/plot}}$$

3.15.16 Yield (t/ha)

The yield per hectare was calculated from per plot yield data and their average was taken. It was measured by the following formula,

$$\text{Yield per hectare (ton)} = \frac{\text{Yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.15.17 Yield increased over control

Yield increased over control was calculated by the following formula

$$\text{Yield increased over control (\%)} = \frac{\text{Treatment yield} - \text{control yield}}{\text{Treatment yield}} \times 100$$

3.16 Statistical analysis

The data obtained for different characters were statistically analyzed using MSTAT-C software. The mean values of all the characters were evaluated and analysis of variance was performing by the 'F' test. The significance of the difference among the treatments means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.17 Economic analysis

The cost of production was calculated to find out the most economic combination of shoot pruning and foliar application of micronutrients. All input cost like the cost for land lease and interests on running capital were computing in the calculation. The interests were calculated @ 13% in simple rate. The market price of bell pepper was considered for estimating the return. Analyses were done according to the procedure of Alam et al. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the influence of calcium and zinc on growth and yield of green chilli. Data on growth, yield contributing characters and yields were recorded. The results have been discussed with the help of tables and graphs and possible interpretations. A summary of the analysis of variance (ANOVA) of the data on different characters have been presented in Appendix III-VII.

4.1 Growth parameters

4.1.1 Plant height

Calcium application to green chilli variety (BARI Morich 2) showed significant variation for plant height at 20, 40, 60 days after transplanting (DAT) and at harvest (Fig 2 and Appendix III). Results revealed that the longest plant (5.03, 11.48, 24.62 and 34.17 cm at 20, 40, 60 DAT and at harvest respectively) was recorded from Ca_3 (35 kg Ca ha^{-1}) which was statistically identical with Ca_2 (27 kg Ca ha^{-1}) at 20, 40 DAT and at harvest. The shortest plant (3.84, 9.69, 21.98 and 30.84 cm at 20, 40, 60 DAT and at harvest respectively) was found from control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}) (Table 2). Similar result was found by El-Tohamy *et al*. (2006) and they observed that Ca fertilization treatments significantly improved plant height.

Plant height of green chilli variety (BARI Morich 2) varied significantly for application of Zn at 20, 40, 60 DAT and at harvest (Fig 3 and Appendix III). Results indicated that the tallest plant (5.24, 11.90, 24.69 and 35.03 cm at 20, 40, 60 DAT and at harvest respectively) was obtained from Zn_2 (5.0 kg Zn ha^{-1}) followed by Zn_1 (2.5 kg Zn ha^{-1}). The shortest plant (3.77, 9.61, 21.73 and 30.39 cm at 20, 40, 60 DAT and at harvest respectively) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}) which was statistically different from all other Zn application effect. Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al*. (2003) which leads to produced tallest plant. Datir *et al*. (2012) reported that micronutrients like iron, zinc, copper and manganese were organically chelated with seed amino acids and the application of amino acid-micronutrient chelate at the concentration of 1.5 and 2.0% resulted in maximum plant height. Similar results were also found by Jamre *et al*. (2010), Rohidas *et al*. (2010) and Swati Barche *et al*. (2011).

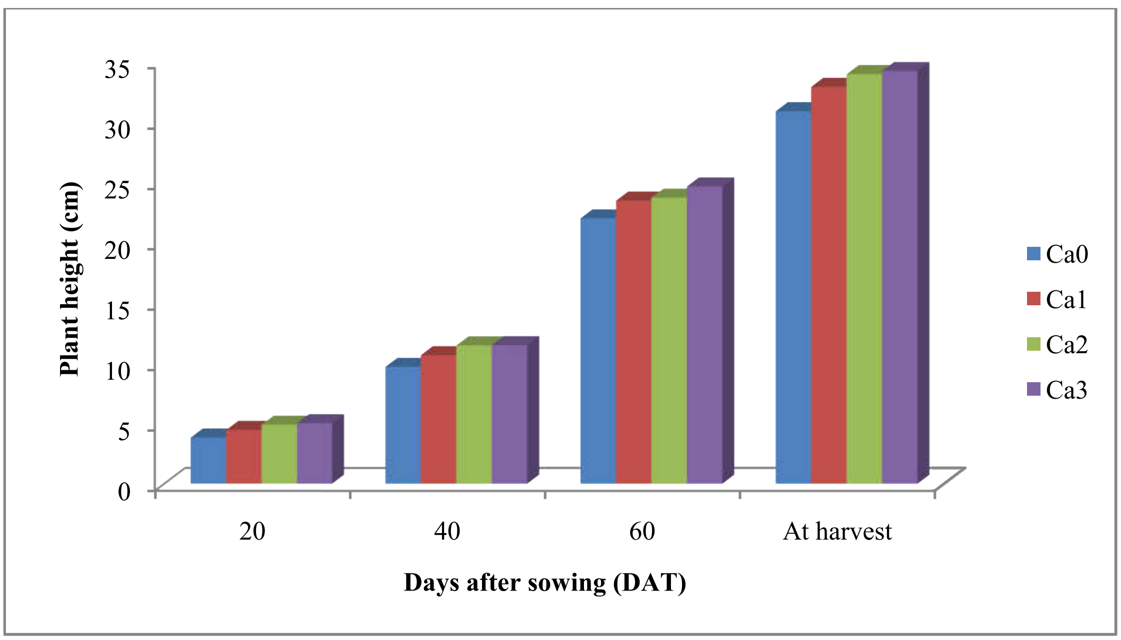


Fig.2. Effect of calcium on plant height at different growth stages of green chilli

Ca_0 = 0 kg ha^{-1}

Ca_1 = 19 kg ha^{-1}

Ca_2 = 27 kg ha^{-1}

Ca_3 = 35 kg ha^{-1}

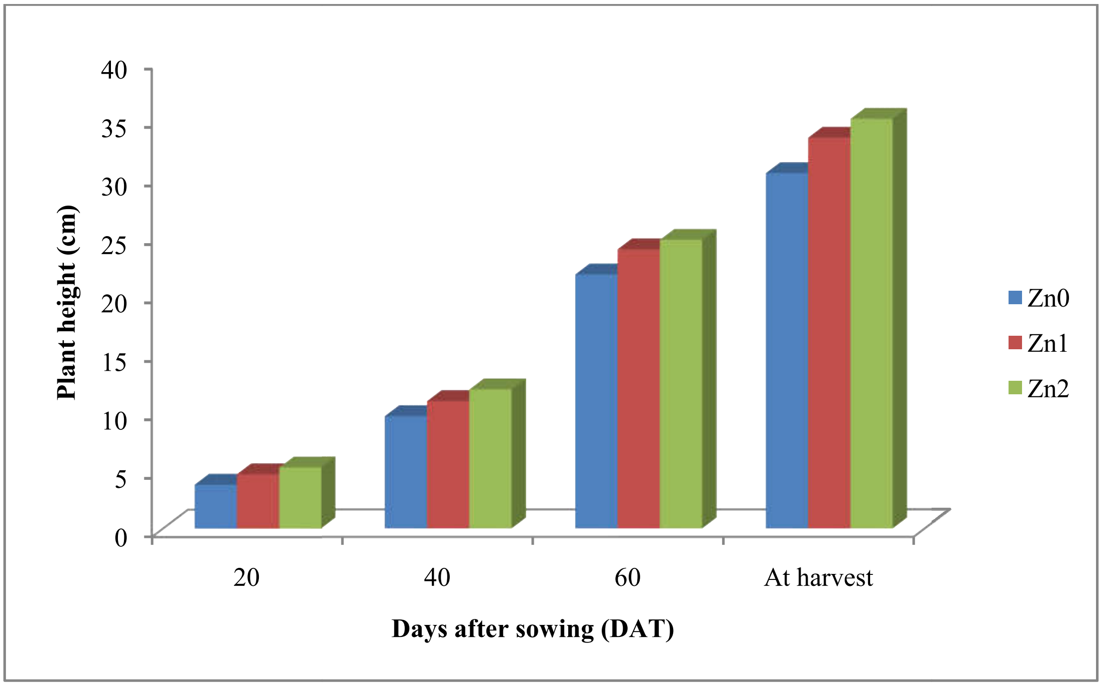


Fig.3. Effect of zinc on plant height at different growth stages of green chilli

Zn_0 = 0 kg ha^{-1}

Zn_1 = 2.5 kg ha^{-1}

Zn_2 = 5.0 kg ha^{-1}

Significant variation was observed due to the interaction effect of Ca and Zn in terms of plant height of green chilli at 20, 40, 60 DAT and at harvest (Table 2 and Appendix III). Results signified that the tallest plant (5.79, 12.69, 26.13 and 36.37 cm at 20, 40, 60 DAT and at harvest respectively) was observed from Ca_3Zn_2 which was statistically identical with Ca_2Zn_1 at all growth stages except 60 DAT followed by Ca_3Zn_1while the shortest plant (3.39, 8.89, 20.28 and 28.76 cm at 20, 40, 60 DAT and at harvest respectively) was recorded from Ca_0Zn_0 followed by Ca_0Zn_2 (Table 2).

Table 2. Combined effect of calcium and zinc on plant height at different growth stages of green chilli

Treatment	Plant height (cm)			
	20 DAT	40 DAT	60 DAT	80 DAT
Ca_0Zn_0	3.39 g[z]	8.89 g	20.28 h	28.76 f
Ca_0Zn_1	4.37 de	10.80 de	23.49 e	33.11 d
Ca_0Zn_2	3.75 fg	9.37 fg	22.17 fg	30.67 e
Ca_1Zn_0	3.67 fg	9.29 g	21.76 g	30.42 e
Ca_1Zn_1	5.09 bc	11.63 bc	24.68 bc	34.45 bc
Ca_1Zn_2	4.67 cd	11.07 d	23.89 de	33.73 cd
Ca_2Zn_0	4.13 ef	10.49 e	22.35 fg	31.25 e
Ca_2Zn_1	5.73 a	12.63 a	24.47 cd	36.21 a
Ca_2Zn_2	4.84 cd	11.28 cd	24.26 cd	34.29 bc
Ca_3Zn_0	3.91 ef	9.79 f	22.55 f	31.13 e
Ca_3Zn_1	5.40 ab	11.96 b	25.19 b	35.01 b
Ca_3Zn_2	5.79 a	12.69 a	26.13 a	36.37 a
$LSD_{0.05}$	0.451	0.473	0.649	1.033
CV(%)	5.621	7.558	9.214	6.347

[z] means, different letter(s) is significantly different by DMRT at $P \leq 0.05$

Ca_0 = 0 kg ha^{-1}
Ca_1 = 19 kg ha^{-1}
Ca_2 = 27 kg ha^{-1}
Ca_3 = 35 kg ha^{-1}

Zn_0 = 0 kg ha^{-1}
Zn_1 = 2.5 kg ha^{-1}
Zn_2 = 5.0 kg ha^{-1}

4.1.2 Number of leaves plant^{-1}

Number of leaves plant^{-1} of green chilli showed statistically significant differences due to application of different Ca doses (Fig 4 and Appendix IV). Results showed that the maximum number of leaves plant^{-1} (6.42, 33.93, 47.17 and 65.00 at 20, 40, 60 DAT and at harvest respectively) was recorded from Ca_3 (35 kg Ca ha^{-1}) which was statistically same with Ca_2 (27 kg Ca ha^{-1}) at all growth stages while the minimum number of leaves plant^{-1}(4.98, 25.80, 33.07 and 46.00 at 20, 40, 60 DAT and at harvest respectively) was obtained from control treatment, Ca_0 (0 kg Ca ha^{-1}) (Table 3) followed by Ca_1 (19 kg Ca ha^{-1}). The present study was similar with the findings of El-Tohamy *et al*. (2006). They observed that Ca fertilizer significantly improved number of leaves per plant. Halina *et al*. (2016) also showed similar result.

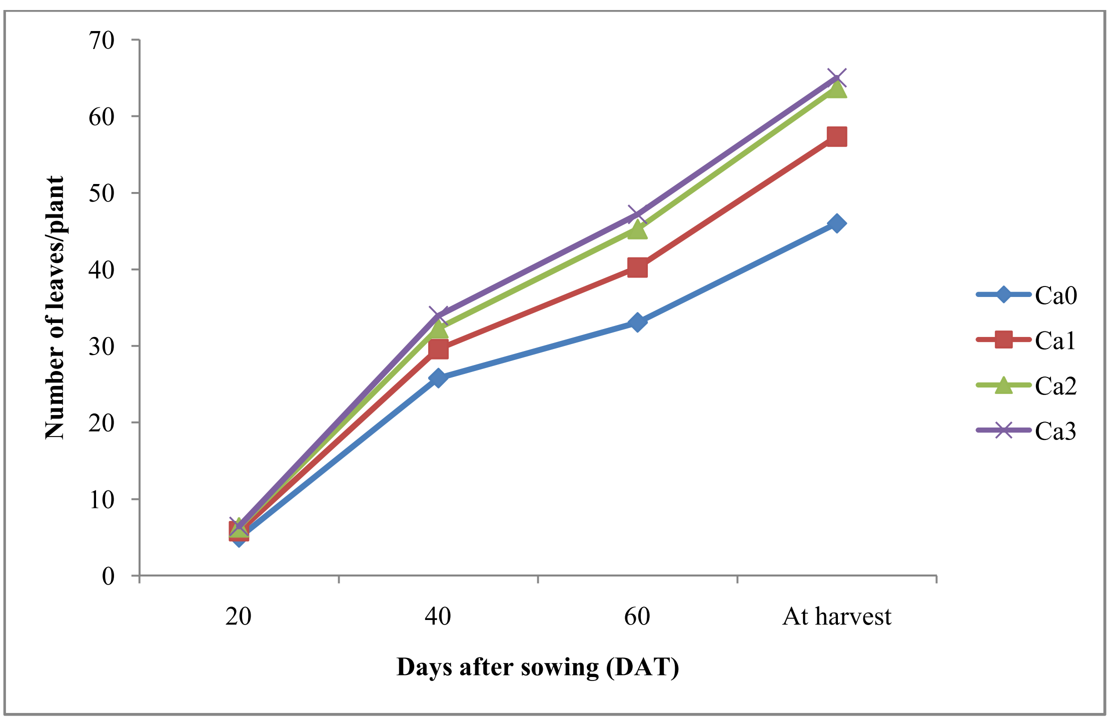


Fig.4. Effect of calcium on number of leaves plant^{-1} at different growth stages of chilli

Ca_0 = 0 kg ha^{-1} Ca_2 = 27 kg ha^{-1}

Ca_1 = 19 kg ha^{-1} Ca_3 = 35 kg ha^{-1}

Number of leaves plant^{-1} of green chilli differed significantly due to the effect of Zn application as micronutrient at 20, 40, 60 DAT and at harvest (Fig 5 and Appendix IV). It was found that the highest number of leaves plant^{-1} (6.60, 34.85, 49.63 and 68.50 at 20, 40, 60 DAT and at harvest respectively) was found from Zn_2 (5.0 kg Zn ha^{-1}) followed by Zn_1 (2.5 kg Zn ha^{-1}) while the minimum number of leaves plant^{-1}(4.98, 25.48, 32.10 and 44.75 at 20, 40, 60 DAT and at harvest respectively) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}) (Table 3). Similar result was also observed by Sindhu and Tiwari (1989).

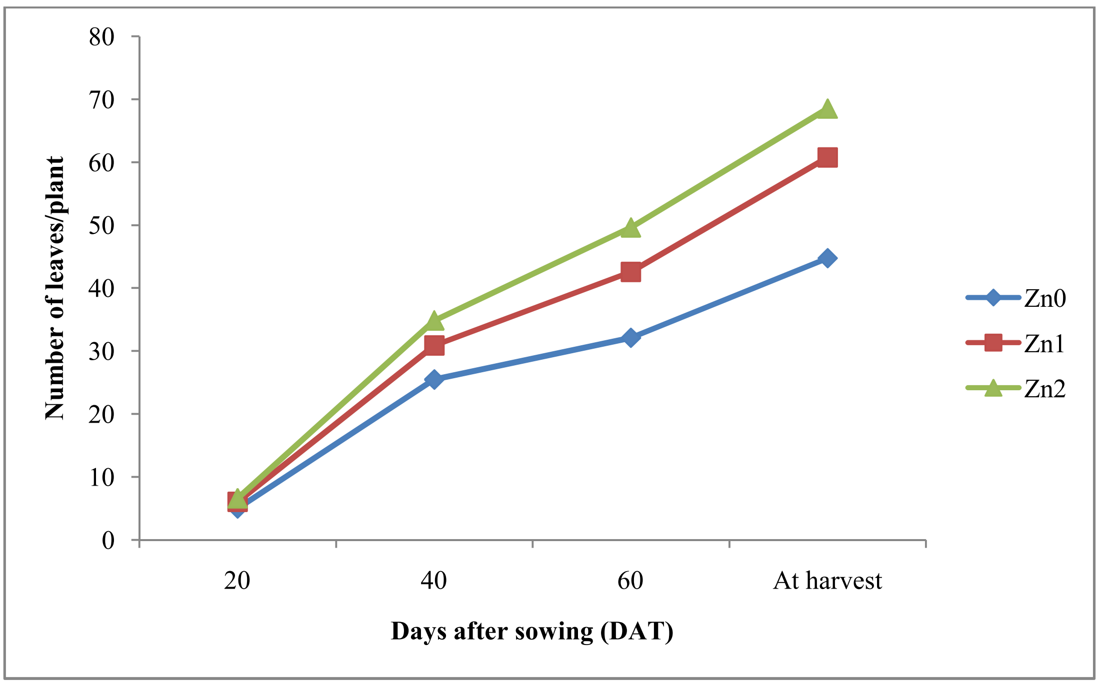


Fig.5. Effect of zinc on number of leaves plant^{-1} at different growth stages of green chilli

Zn_0 = 0 kg ha^{-1}

Zn_1 = 2.5 kg ha^{-1}

Zn_2 = 5.0 kg ha^{-1}

Ca and Zn application to green chilli plants showed significant variation due to the interaction effect on number of leaves $plant^{-1}$ at 20, 40, 60 DAT and at harvest (Table 3 and Appendix IV). Results demonstrated that the maximum number of leaves $plant^{-1}$ (7.10, 38.80, 56.00 and 75.00 at 20, 40, 60 DAT and at harvest respectively) was recorded from Ca_3Zn_2which was closely followed by Ca_2Zn_1 and Ca_3Zn_1, whereas the minimum number of leaves $plant^{-1}$ (3.90, 22.20, 28.40 and 35.00 at 20, 40, 60 DAT and at harvest respectively) was observed from Ca_0Zn_0followed by Ca_1Zn_0 at all growth stages.

Table 3. Combined effect of calcium and zinc on number of leaves $plant^{-1}$ at different growth stages of chilli

Treatment	Number of leaves $plant^{-1}$			
	20 DAT	40 DAT	60 DAT	80 DAT
Ca_0Zn_0	3.90 g^z	22.20 h	28.40 g	35.00 h
Ca_0Zn_1	5.88 d	28.80 de	38.80 de	58.00 e
Ca_0Zn_2	5.15 f	26.40 fg	32.00 fg	45.00 g
Ca_1Zn_0	5.00 f	25.00 g	31.70 fg	43.00 g
Ca_1Zn_1	6.40 bc	33.60 c	48.40 bc	67.00 c
Ca_1Zn_2	6.00 cd	30.10 d	40.60 d	62.00 d
Ca_2Zn_0	5.60 de	27.70 ef	35.00 ef	52.00 f
Ca_2Zn_1	7.00 a	38.20 a	55.30 a	74.00 ab
Ca_2Zn_2	6.30 c	31.00 d	45.50 c	65.00 cd
Ca_3Zn_0	5.40 ef	27.00 e-g	33.30 f	49.00 f
Ca_3Zn_1	6.75 ab	36.00 b	52.20 ab	71.00 b
Ca_3Zn_2	7.10 a	38.80 a	56.00 a	75.00 a
$LSD_{0.05}$	0.394	2.099	3.875	3.329
CV(%)	6.226	8.314	8.416	10.583

^{z} means, different letter(s) is significantly different by DMRT at $P \leq 0.05$

$Ca_0 = 0$ kg ha^{-1}	$Zn_0 = 0$ kg ha^{-1}
$Ca_1 = 19$ kg ha^{-1}	$Zn_1 = 2.5$ kg ha^{-1}
$Ca_2 = 27$ kg ha^{-1}	$Zn_2 = 5.0$ kg ha^{-1}
$Ca_3 = 35$ kg ha^{-1}	

4.1.3 Number of branches plant^{-1}

Calcium application to green chilli showed significant variation for number of branches plant^{-1} at 40, 60 days after transplanting (DAT) and at harvest (Fig 6 and Appendix V. Results revealed that the highest number of branches plant^{-1} (3.71, 10.00 and 11.88 at 40, 60 DAT and at harvest respectively) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically identical with Ca_3 (35 kg Ca ha^{-1}) at all growth stages followed by Ca_1 (19 kg Ca ha^{-1}). The lowest number of branches plant^{-1} (2.47, 7.52 and 7.94 at 40, 60 DAT and at harvest respectively) was found from control treatment, Ca_0 (0 kg Ca ha^{-1}) (Table 4).Similar results were also found by Halina *et al*. (2016) and El-Tohamy *et al*. (2006).

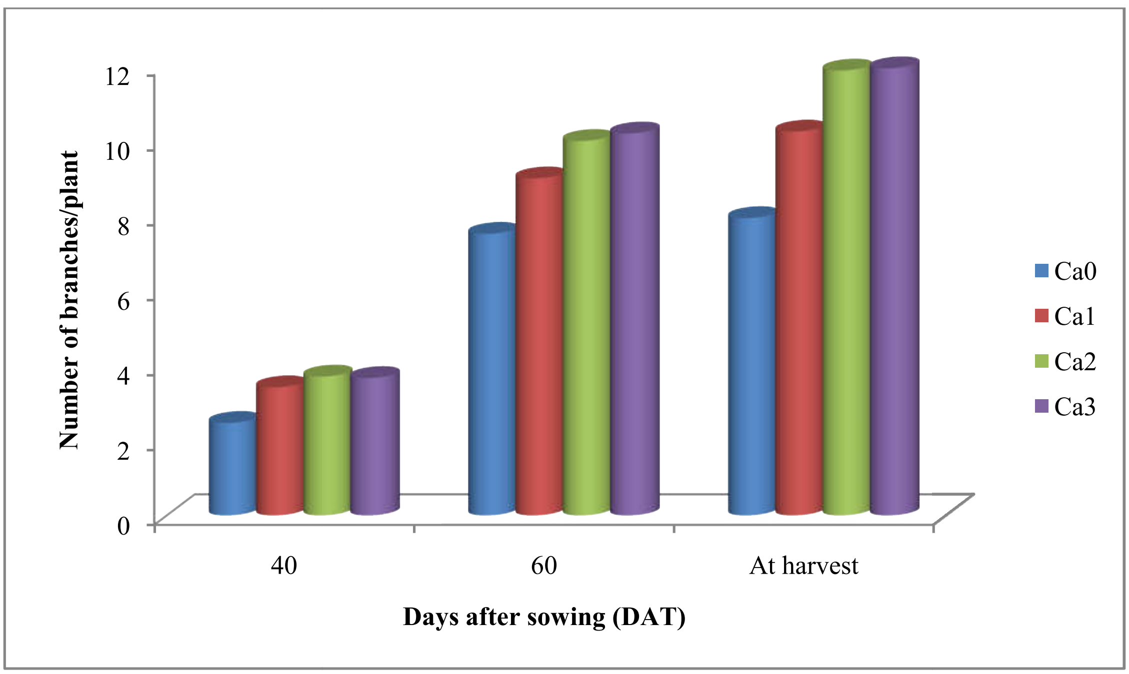


Fig.6. Effect of calcium on number of branches plant^{-1} at different growth stages of chilli

Ca_0 = 0 kg ha^{-1}

Ca_1 = 19 kg ha^{-1}

Ca_2 = 27 kg ha^{-1}

Ca_3 = 35 kg ha^{-1}

Number of branches plant^{-1} of green chilli varied significantly for application of Zn at 40, 60 DAT and at harvest (Fig 7 and Appendix V). Results indicated that the highest number of branches plant^{-1} (3.85, 10.65 and 12.34 at 40, 60 DAT and at harvest respectively) was obtained from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}). The lowest number of branches plant^{-1} (2.46, 7.51 and 8.19 at 40, 60 DAT and at harvest respectively) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}) which was statistically different from all other Zn application effect. The present finding was supported by the findings of Singh *et al*. (1989), Swati Barche *et al*. (2011) and Datir *et al*. (2012).

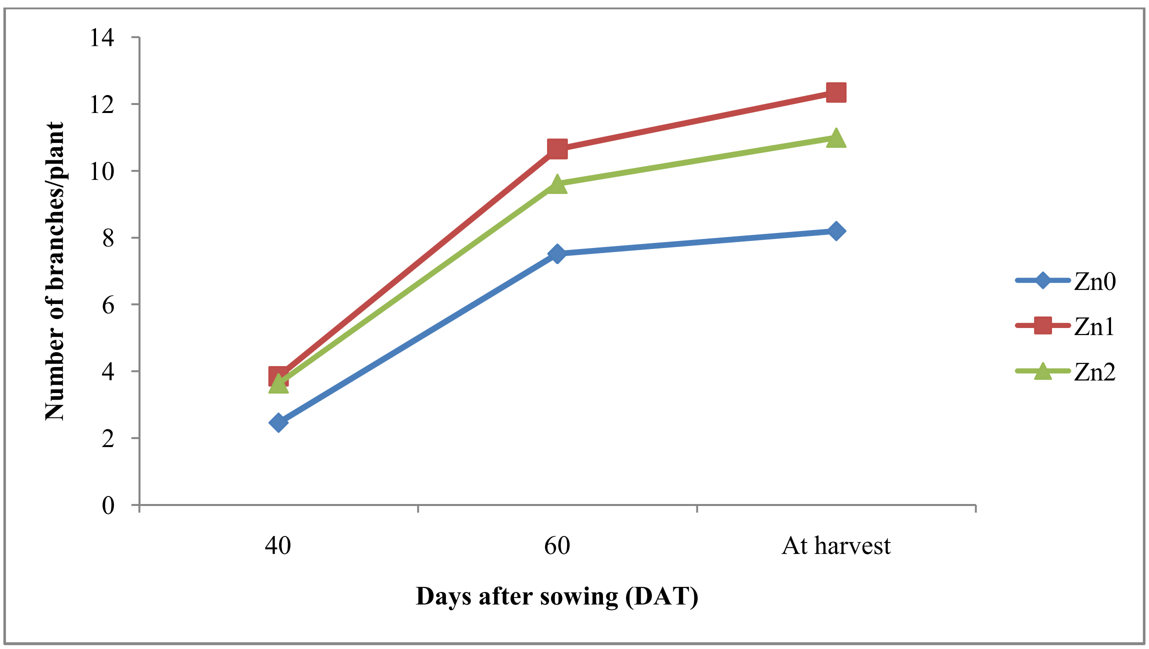


Fig.7. Effect of zinc on number of branches plant^{-1} at different growth stages of green chilli

Zn_0 = 0 kg ha^{-1}

Zn_1 = 2.5 kg ha^{-1}

Zn_2 = 5.0 kg ha^{-1}

Significant variation was observed due to the interaction effect of Ca and Zn in terms of number of branches plant^{-1} of green chilli at 40, 60 DAT and at harvest (Table 4 and Appendix V). Results signified that the highest number of branches plant^{-1} (4.12, 11.62 and 13.84 at 40, 60 DAT and at harvest respectively) was observed from Ca_2Zn_1 which was statistically identical with Ca_3Zn_1at all growth stages followed by Ca_3Zn_2 while the lowest number of branches plant^{-1} (1.43, 5.67 and 5.90 at 40, 60 DAT and at harvest respectively) was recorded from Ca_0Zn_0 followed by Ca_1Zn_0 and Ca_0Zn_2.

Table 4. Combined effect of calcium and zinc on number of branches plant^{-1} at different growth stages of green chilli

Treatment	Number of branches plant^{-1}		
	40 DAT	60 DAT	80 DAT
Ca_0Zn_0	1.43 e^z	5.67 h	5.90 g
Ca_0Zn_1	3.26 b	9.42 de	9.96 e
Ca_0Zn_2	2.72 cd	7.48 g	7.96 f
Ca_1Zn_0	2.55 d	7.32 g	7.72 f
Ca_1Zn_1	3.92 a	10.00 cd	11.94 c
Ca_1Zn_2	3.78 a	9.67 d	11.10 d
Ca_2Zn_0	3.00 bc	8.88 e	9.70 e
Ca_2Zn_1	4.12 a	11.62 a	13.84 a
Ca_2Zn_2	4.00 a	10.42 bc	12.10 bc
Ca_3Zn_0	2.86 cd	8.16 f	9.44 e
Ca_3Zn_1	4.10 a	11.55 a	13.60 a
Ca_3Zn_2	4.06 a	10.88 b	12.78 b
$LSD_{0.05}$	0.321	0.643	0.694
CV(%)	7.211	6.347	8.216

^{z} means, different letter(s) is significantly different by DMRT at $P \leq 0.05$

Ca_0 = 0 kg ha^{-1}
Ca_1 = 19 kg ha^{-1}
Ca_2 = 27 kg ha^{-1}
Ca_3 = 35 kg ha^{-1}

Zn_0 = 0 kg ha^{-1}
Zn_1 = 2.5 kg ha^{-1}
Zn_2 = 5.0 kg ha^{-1}

4.2 Yield contributing parameters

4.2.1 Total dry mass plant^{-1}

Ca effect of green chilli showed significant variation on total dry mass plant^{-1} (Table 5 and Appendix VI). Result revealed that the highest total dry mass plant^{-1} (89.25 g) was found from Ca_2 (27 kg Ca ha^{-1}) followed by Ca_3 (35 kg Ca ha^{-1}) where the lowest total dry mass plant^{-1} (70.58 g) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}). Rubio *et al*. (2010) showed that Ca application significantly increase dry matter production in pepper plant.

Total dry mass plant^{-1} of green chilli differed significantly due to the effect of Zn application as micronutrient (Table 5 and Appendix VI). It was found that the highest total dry mass plant^{-1} (92.61 g) was found from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) while the lowest total dry mass plant^{-1} (68.63 g) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}). Similar results were also found by Shil *et al*. (2013) and Jamre *et al*.(2010).

Combined effect of Ca and Zn application to green chilli plants showed significant variation (Table 5 and Appendix VI). Results demonstrated that the highest total dry mass plant^{-1} (98.36 g) was recorded from Ca_2Zn_1 which was statistically similar with Ca_3Zn_1 followed by Ca_3Zn_2 and Ca_1Zn_1, whereas the lowest total dry mass plant^{-1} (57.16 g) was observed from Ca_0Zn_0 followed by Ca_1Zn_0.

4.2.2 Stem base diameter

Different levels of Ca application showed significant effect on stem base diameter of chilli plant (Table 5 and Appendix VI). Results exposed the highest stem base diameter (1.32 cm) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}). In comparison, the lowest stem base diameter (0.92

cm) was observed in control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Stem base diameter of green chilli plant was significantly influenced by different levels of Zn application (Table 5 and Appendix VI). Results signified that the highest stem base diameter (1.44 cm) was recorded from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}). But, the lowest stem base diameter (0.91 cm) was observed in control treatment, Zn_0 (0 kg Zn ha^{-1}).

Interaction of Ca and Zn significantly affected the stem base diameter of green chilli (Table 5 and Appendix VI). Results pointed out that the highest stem base diameter (1.67 cm) was recorded from the treatment combination of Ca_2Zn_1 which was statistically identical with Ca_3Zn_1 followed by Ca_3Zn_2, Ca_1Zn_1 and Ca_2Zn_2. On the other hand, the lowest stem base diameter (0.77 cm) was observed in control treatment combination (Ca_0Zn_0) which was statistically similar with Ca_0Zn_2 and Ca_1Zn_0 followed by Ca_3Zn_0.

4.2.3 Days to flower initiation

Ca effect of green chilli showed significant variation on days to flower initiation (Table 5 and Appendix VI). Result revealed that the lowest days required for flower initiation (47.50 days) was found from Ca_3 (35 kg Ca ha^{-1}) which was statistically same with Ca_2 (27 kg Ca ha^{-1}) where the highest days to flower initiation (52.83 days) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Days to flower initiation of chilli differed significantly due to different levels of Zn application (Table 5 and Appendix VI). It was found that the lowest days to flower initiation (46.80 days) was found from Zn_2 (5.0 kg Zn ha^{-1}) followed by Zn_1 (2.5 kg Zn ha^{-1}) while the highest days to flower initiation (52.58 days) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}).

Combined effect of Ca and Zn application to green chilli plants showed significant variation on days to flower initiation (Table 5 and Appendix VI). Results demonstrated that the lowest days to flower initiation (44.60 days) was recorded from Ca_3Zn_2which was statistically identical with Ca_2Zn_1 followed by Ca_1Zn_1, Ca_1Zn_2, Ca_2Zn_2 and Ca_3Zn_1 whereas the highest days to flower initiation (56.30 days) was observed from Ca_0Zn_0 followed by Ca_1Zn_0 and Ca_0Zn_2.

4.2.4 Number of flowers plant^{-1}

Different levels of Ca application showed significant effect on number of flowers plant^{-1} of green chilli (Table 5 and Appendix VI). Results exposed the highest number of flowers plant^{-1} (69.65) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}). In comparison, the lowest number of flowers plant^{-1}(59.27) was observed in control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Number of flowers plant^{-1} of green chilli plant was significantly influenced by different levels of Zn application (Table 5 and Appendix VI). Results signified that the highest number of flowers plant^{-1} (71.90) was recorded from Zn_1 (2.5 kg Zn ha^{-1}) which was statistically identical with Zn_2 (5.0 kg Zn ha^{-1}). But, the lowest number of flowers plant^{-1}(58.56) was observed in control treatment, Zn_0 (0 kg Zn ha^{-1}). Supported results was also achieved by Swati Barche *et al*. (2011).

Interaction of Ca and Zn significantly affected the number of flowers plant^{-1} of chilli (Table 5 and Appendix VI). Results pointed out that the highest number of flowers plant^{-1} (76.60) was recorded from the treatment combination of Ca_2Zn_1 which was statistically identical with Ca_3Zn_1 and closely followed by Ca_3Zn_2. On the other hand, the lowest number of flowers plant^{-1} (53.70) was observed in control treatment combination (Ca_0Zn_0) which was followed by Ca_0Zn_2, Ca_1Zn_0 and Ca_3Zn_0.

4.2.5 Days to first Fruiting

Effect of Ca on green chilli plants showed significant variation on days to first fruiting (Table 5 and Appendix VI). Result revealed that the lowest days to first fruiting (50.20 days) was found from Ca_3 (35 kg Ca ha^{-1}) which was statistically same with Ca_2 (27 kg Ca ha^{-1}) where the highest days to first fruiting (55.73 days) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Days to first fruiting of green chilli differed significantly due to different levels of Zn application (Table 5 and Appendix VI). It was found that the lowest days to first fruiting (49.48 days) was found from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) while the highest days to first fruiting (55.85 days) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}).

Combined effect of Ca and Zn application to green chilli plants showed significant variation on days to first fruiting (Table 5 and Appendix VI). Results demonstrated that the lowest days to first fruiting (47.50 days) was recorded from Ca_3Zn_1 which was statistically identical with Ca_2Zn_1 followed by Ca_3Zn_2 whereas the highest days to first fruiting (60.10 days) was observed from Ca_0Zn_0 followed by Ca_1Zn_0.

4.2.6 Number of fruits $plant^{-1}$

Different levels of Ca application showed significant effect on number of fruits $plant^{-1}$ of green chilli (Table 5 and Appendix VI). Results exposed the highest number of fruits $plant^{-1}$ (59.63) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}). In comparison, the lowest number of fruits $plant^{-1}$ (49.07) was observed in control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}). The results obtained from the present findings was conformity with the findings of Halina *et al*. (2016) and Rubio *et al*. (2010). They found that Ca had significant effect on number of fruits $plant^{-1}$.

Number of fruits plant^{-1} of green chilli plant was significantly influenced by different levels of Zn application (Table 5 and Appendix VI). Results signified that the highest number of fruits plant^{-1} (62.18) was recorded from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}). But, the lowest number of fruits plant^{-1} (48.48) was observed in control treatment, Zn_0 (0 kg Zn ha^{-1}). The results obtained by Swati Barche *et al*. (2011), Mahesh Kumar and Sen (2005), Patil *et al*. (2010) and Swati barche *et al*. (2011) supported the present study.

Interaction of Ca and Zn significantly affected the number of fruits plant^{-1} of green chilli (Table 5 and Appendix VI). Results confirmed that the highest number of fruits plant^{-1} (68.60) was recorded from the treatment combination of Ca_2Zn_1 followed by Ca_3Zn_1 and Ca_3Zn_2. On the other hand, the lowest number of fruits plant^{-1} (44.30) was observed in control treatment combination (Ca_0Zn_0) which was followed by Ca_0Zn_2, Ca_1Zn_0 and Ca_3Zn_0.

4.2.7 Fruit length

Different levels of Ca application showed significant effect on fruit length of green chilli plant. Results exposed the highest fruit length (6.70 cm) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}). In comparison, the lowest fruit length (5.87 cm) was observed in control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Fruit length of green chilli plant was significantly influenced by different levels of Zn application. Results signified that the highest fruit length (6.89 cm) was recorded from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) where the lowest fruit length (5.82 cm) was observed in control treatment, Zn_0 (0 kg Zn ha^{-1}). Similar result was also observed by Mahesh Kumar and Sen (2005).

Interaction of Ca and Zn significantly affected the fruit length of green chilli. Results indicated that the highest fruit length (7.24 cm) was recorded from the treatment combination of Ca_2Zn_1 which was statistically identical with Ca_3Zn_1 and

Ca_3Zn_2 which was closely followed by Ca_1Zn_1. Alternatively, the lowest fruit length (5.40 cm) was observed in control treatment combination (Ca_0Zn_0) followed byCa_0Zn_2, Ca_1Zn_0 and Ca_3Zn_0.

4.2.8 Fruit diameter

Different levels of Ca application showed significant effect on fruit diameter of green chilli plant. Results exposed the highest fruit diameter (0.97 cm) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}). In comparison, the lowest fruit diameter (0.87 cm) was observed in control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Fruit diameter of green chilli plant was significantly influenced by different levels of Zn application. Results signified that the highest fruit diameter (1.01 cm) was recorded from Zn_2 (5.0 kg Zn ha^{-1}) followed by Zn_1 (2.5 kg Zn ha^{-1}) where the lowest fruit diameter (0.87 cm) was observed in control treatment, Zn_0 (0 kg Zn ha^{-1}).

Interaction of Ca and Zn significantly affected the fruit diameter of green chilli. Results indicated that the highest fruit diameter (1.12 cm) was recorded from the treatment combination of Ca_2Zn_2followed by Ca_2Zn_1 and Ca_1Zn_1. Alternatively, the lowest fruit diameter (0.82 cm) was observed in control treatment combination (Ca_0Zn_0) followed by Ca_0Zn_2 and Ca_1Zn_0, Ca_2Zn_0 and Ca_3Zn_0.

4.2.9 Number of seeds fruit^{-1}

Different levels of Ca application showed significant effect on number of seeds fruit^{-1} of green chilli. Results exposed the highest number of seeds fruit^{-1} (72.60) was recorded from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}). Again, the lowest number of seeds fruit^{-1} (59.00) was observed in control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Number of seeds $fruit^{-1}$ of green chilli plant was significantly influenced by different levels of Zn application. Results signified that the highest number of seeds $fruit^{-1}$ (76.30) was recorded from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) where the lowest number of seeds $fruit^{-1}$ (57.80) was observed in control treatment, Zn_0 (0 kg Zn ha^{-1}). Dongre *et al*. (2000) also showed similar results which supported the present findings.

Interaction of Ca and Zn significantly affected the number of seeds $fruit^{-1}$ of green chilli. Results confirmed that the highest number of seeds $fruit^{-1}$ (83.00) was recorded from the treatment combination of Ca_2Zn_1 which was closely followed by Ca_3Zn_1. Similarly, the lowest number of seeds $fruit^{-1}$ (51.70) was observed in control treatment combination (Ca_0Zn_0) followed by Ca_0Zn_2 andCa_1Zn_0.

4.2.10 Weight of 1000 seeds

Significant variation was found for different levels of Ca application to green chilli plants on 1000 seed weight. Result revealed that the highest 1000 seed weight (7.85 g) was found from Ca_2 (27 kg Ca ha^{-1}) which was statistically same with Ca_3 (35 kg Ca ha^{-1}) where the lowest 1000 seed weight (6.78 g) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Weight of 1000 seeds of green chilli differed significantly due to the effect of Zn application as micronutrient. It was found that the highest 1000 seed weight (8.10 g) was found from Zn_1 (2.5 kg Zn ha^{-1}) which was statistically same with Zn_2 (5.0 kg Zn ha^{-1}) while the lowest 1000 seed weight (6.76 g) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}).

Combined effect of Ca and Zn application to green chilli plants showed significant variation on 1000 seed weight. Results demonstrated that the highest 1000 seed weight (8.52 g) was recorded from Ca_2Zn_1 which was statistically similar with $Ca_3Zn_1$and Ca_3Zn_2 whereas the lowest 1000 seed weight (5.88 g) was observed from Ca_0Zn_0 followed by Ca_0Zn_2, Ca_1Zn_0, Ca_3Zn_0.

Table 5. Effect of calcium and zinc on yield contributing parameters of green chilli

Treatment	Total dry mass $plant^{-1}$ (g)	Stem base diameter (cm)	Days to flower initiation	Number of flowers $plant^{-1}$	Days to first Fruiting	Number of fruits $plant^{-1}$
Effect of calcium (Ca)						
Ca_0	70.58 d^z	0.92 c	52.83 a	59.27 c	55.73 a	49.07 c
Ca_1	80.51 c	1.13 b	49.53 b	65.60 b	52.23 b	54.78 b
Ca_2	89.25 a	1.32 a	47.80 c	69.27 a	50.87 c	59.60 a
Ca_3	87.06 b	1.34 a	47.50 c	69.65 a	50.20 c	59.63 a
$LSD_{0.05}$	2.123	0.161	1.715	3.365	1.143	3.271
CV(%)	10.539	6.355	8.243	11.627	9.384	8.679
Effect of zinc (Zn)						
Zn_0	68.63 c^z	0.91 c	52.58 a	58.56 b	55.85 a	48.48 c
Zn_1	92.61 a	1.44 a	48.88 b	71.90 a	49.48 c	62.18 a
Zn_2	84.31 b	1.18 b	46.80 c	67.38 a	51.45 b	56.66 b
$LSD_{0.05}$	5.260	0.227	1.350	4.587	1.772	4.460
CV(%)	10.539	6.355	8.243	11.627	9.384	8.679
Combined effect of Ca and Zn						
Ca_0Zn_0	57.16 h^z	0.77 h	56.30 a	53.70 g	60.10 a	44.30 g
Ca_0Zn_1	84.32 d	1.10 d-f	50.00 d	64.80 d	52.80 cd	54.20 d
Ca_0Zn_2	70.27 f	0.90 gh	52.20 bc	59.30 f	54.30 bc	48.70 f
Ca_1Zn_0	64.18 g	0.88 gh	52.70 b	57.70 f	55.50 b	48.20 f
Ca_1Zn_1	92.24 b	1.32 bc	47.60 e	71.00 bc	50.00 e	60.40 c
Ca_1Zn_2	85.11 d	1.18 c-e	48.30 e	68.10 c	51.20 de	55.75 d
Ca_2Zn_0	80.68 e	1.04 e-g	50.40 d	62.60 de	54.00 bc	51.80 e
Ca_2Zn_1	98.36 a	1.67 a	45.00 f	76.60 a	47.60 f	68.60 a
Ca_2Zn_2	88.71 c	1.25 b-d	48.00 e	68.60 c	51.00 de	58.40 c
Ca_3Zn_0	72.48 f	0.96 fg	50.90 cd	60.25 ef	53.80 bc	49.60 f
Ca_3Zn_1	95.53 ab	1.65 a	47.00 e	75.20 a	47.50 f	65.50 b
Ca_3Zn_2	93.16 b	1.40 b	44.60 f	73.50 ab	49.30 ef	63.80 b
$LSD_{0.05}$	3.435	0.1606	1.654	3.096	1.963	2.019
CV(%)	10.539	6.355	8.243	11.627	9.384	8.679

^{z} means, different letter(s) is significantly different by DMRT at $P \leq 0.05$

Ca_0 = 0 kg ha^{-1} Zn_0 = 0 kg ha^{-1}
Ca_1 = 19 kg ha^{-1} Zn_1 = 2.5 kg ha^{-1}
Ca_2 = 27 kg ha^{-1} Zn_2 = 5.0 kg ha^{-1}
Ca_3 = 35 kg ha^{-1}

4.3 Yield parameters

4.3.1 Average fruit weight

Significant variation was found for different levels of Ca application to green chilli plants on average fruit weight. Result revealed that the highest average fruit weight (2.66 g) was found from Ca_2 (27 kg Ca ha^{-1}) which was statistically same with Ca_3 (35 kg Ca ha^{-1}) where the lowest average fruit weight (1.71 g) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).

Average fruit weight of green chilli differed significantly due to the effect of Zn application as micronutrient. It was found that the highest average fruit weight (2.84 g) was found from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) where the lowest average fruit weight (1.71 g) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}). Similar result was also found by Mahesh Kumar and Sen (2005) which was conformity with the present findings.

Combined effect of Ca and Zn application to green chilli plants showed significant variation on average fruit weight. Results demonstrated that the highest average fruit weight (3.28 g) was recorded from Ca_2Zn_1 which was statistically similar with Ca_3Zn_1 whereas the lowest average fruit weight (1.32 g) was observed from Ca_0Zn_0 which was statistically identical with Ca_1Zn_0 and closely followed by Ca_0Zn_2.

4.3.2 Fruit yield plant^{-1}

Different levels of Ca application to green chilli plants had significant effect on fruit yield plant^{-1} (Table 6 and Appendix VII). Result revealed that the highest fruit yield plant^{-1} (243.80 g) was found from Ca_2 (27 kg Ca ha^{-1}) which was statistically same with Ca_3 (35 kg Ca ha^{-1}) where the lowest fruit yield plant^{-1} (174.80 g) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).Similar result was found by Halina *et al*. (2016) and Rubio *et al*.

(2010). They found that Ca had significant effect on number of fruits plant^{-1} and it helps to increase fruit yield plant^{-1}.

Significant variation was found for fruit yield plant^{-1} of green chilli influenced by different levels of Zn application (Table 6 and Appendix VII). It was found that the highest fruit yield plant^{-1} (257.10 g) was found from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) where the lowest fruit yield plant^{-1} (173.30 g) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}). Similar finding was also observed by Swati barche *et al*. (2011).

Fruit yield plant^{-1} of green chilli was significantly affected by combined effect of Ca and Zn (Table 6 and Appendix VII). Results verified that the highest fruit yield plant^{-1} (280.20 g) was recorded from Ca_2Zn_1 which was statistically similar with Ca_3Zn_1 whereas the lowest fruit yield plant^{-1} (133.50 g) was observed from Ca_0Zn_0 which was followed by Ca_0Zn_2, Ca_1Zn_0.

4.3.3 Fruit yield ha^{-1}

Different levels of Ca application to green chilli plants had significant effect on fruit yield ha^{-1} (Table 6 and Appendix VII). Result revealed that the highest fruit yield ha^{-1} (10.30 t) was found from Ca_2 (27 kg Ca ha^{-1}) which was statistically identical with Ca_3 (35 kg Ca ha^{-1}) where the lowest fruit yield ha^{-1} (7.59 t) was obtained by control treatment, Ca_0 (0 kg Ca ha^{-1}) followed by Ca_1 (19 kg Ca ha^{-1}).Similar result was found by Rubio *et al*. (2010). They found that fruit yield of chilli was increased by Ca application. Similar result was also found by Shivaprasad *et al*. (2009) and El-Tohamy *et al*. (2006).

Significant variation was found for fruit yield ha^{-1} of green chilli influenced by different levels of Zn application (Table 6 and Appendix VII). It was found that the highest fruit yield ha^{-1} (10.90 t) was found from Zn_1 (2.5 kg Zn ha^{-1}) followed by Zn_2 (5.0 kg Zn ha^{-1}) where the lowest fruit yield ha^{-1} (7.56 t) was found from control treatment, Zn_0 (0 kg Zn ha^{-1}). Similar results was also observed by Patil *et al*. (2011), Rohidas *et al*. (2010) and Sindhu and Tiwari (1989).

Fruit yield ha^{-1} of green chilli was significantly affected by the combination of Ca and Zn application (Table 6 and Appendix VII). Results verified that the highest fruit yield ha^{-1} (12.62 t) was recorded from Ca_2Zn_1 which was statistically similar with Ca_3Zn_1 whereas the lowest fruit yield ha^{-1} (6.54 t) was observed from Ca_0Zn_0 which was statistically similar with Ca_0Zn_2 and Ca_1Zn_0.

4.3.4 Yield increased over control (%)

Application of Ca at different levels to the soil for yield of green chilli variety (BARI morich 2) was significant in terms of yield increased over control (%) (Table 6 and Appendix VII). Results revealed that the highest increased yield over control (57.19%) was observed from Ca_2 (27 kg Ca ha^{-1}) which was statistically equal with Ca_3 (35 kg Ca ha^{-1}) (57.18%) where the lowest yield increased over control (34.66%) was found from Ca_1 (19 kg Ca ha^{-1}).

Different levels of Zn application for yield of green chilli plants under the present study gave significantly increased yield over control (Table 6 and Appendix VII). It was found that the highest increased yield over control (66.77%) was found from Zn_1 (2.5 kg Zn ha^{-1}) where the lowest increased yield over control (41.59%) was found from Zn_2 (5.0 kg Zn ha^{-1}).

In terms of yield increased over control (%), combined effect of Ca and Zn showed significant influence considering yield of green chilli over control (Table 6 and Appendix VII). Results exposed that the highest increased yield over control (92.97%) was found from Ca_2Zn_1 followed by Ca_3Zn_1 where the lowest increased yield over control (7.65%) was found from Ca_1Zn_0 which was statistically same with Ca_0Zn_2.

Table 6. Effect of calcium and zinc on yield parameters of green chilli

Treatment	Fruit yield plant^{-1} (g)	Yield (t ha^{-1})	Yield increased over control (%)
Effect of calcium (Ca)			
Ca_0	174.80 c^z	7.59 c	--
Ca_1	217.90 b	8.81 b	34.66 b
Ca_2	243.80 a	10.30 a	57.19 a
Ca_3	243.40 a	10.28 a	57.18 a
$LSD_{0.05}$	6.260	0.9815	3.362
CV(%)	9.338	6.522	7.429
Effect of zinc (Zn)			
Zn_0	173.30 c^z	7.56 c	--
Zn_1	257.10 a	10.9 a	66.67 a
Zn_2	229.60 b	9.26 b	41.59 b
$LSD_{0.05}$	6.763	0.999	5.268
CV(%)	9.338	6.522	7.429
Combined effect of Ca and Zn			
Ca_0Zn_0	133.50 j^z	6.54 h	--
Ca_0Zn_1	220.30 f	9.00 e	37.61 fg
Ca_0Zn_2	170.70 i	7.24 gh	10.70 i
Ca_1Zn_0	162.60 i	7.04 gh	7.65 i
Ca_1Zn_1	255.30 c	10.20 cd	55.96 d
Ca_1Zn_2	237.70 e	9.18 e	40.37 f
Ca_2Zn_0	204.40 g	8.70 ef	33.03 g
Ca_2Zn_1	280.20 a	12.62 a	92.97 a
Ca_2Zn_2	246.80 d	9.52 de	45.57 e
Ca_3Zn_0	192.60 h	7.96 fg	21.71 h
Ca_3Zn_1	272.60 ab	11.78 ab	80.12 b
Ca_3Zn_2	265.10 b	11.10 bc	69.72 c
$LSD_{0.05}$	8.356	0.9458	5.186
CV(%)	9.338	6.522	7.429

^{z} means, different letter(s) is significantly different by DMRT at $P \leq 0.05$

$Ca_0 = 0$ kg ha^{-1} $Zn_0 = 0$ kg ha^{-1}
$Ca_1 = 19$ kg ha^{-1} $Zn_1 = 2.5$ kg ha^{-1}
$Ca_2 = 27$ kg ha^{-1} $Zn_2 = 5.0$ kg ha^{-1}
$Ca_3 = 35$ kg ha^{-1}

4.4 Economic performance

The cost and return analysis were done and have been presented in Table 7 and Appendix VIII. Material (A), non-material (B) and overhead cost were recorded for all the treatments of unit plot and calculated on per hectare basis (yield ha^{-1}), the price of green chilli per ton at the local market rates were considered.

The total cost of production ranges between Tk. 100968 ha^{-1} and Tk. 103366 ha^{-1} among the different treatment combination. The variation was due to different doses of Ca and Zn treatment cost. The highest cost of production Tk.103366 ha^{-1} was involved in the treatment combination of Ca_3Zn_2 followed by Ca_2Zn_2 while the lowest cost of production Tk.100968 ha^{-1} was involved in the combination of Ca_0Zn_0 followed by Ca_0Zn_1(Table 7 and Appendix VII).

Gross return from the different treatment combinations range between Tk.196200 ha^{-1} and Tk.378600 ha^{-1}. The highest gross return Tk.378600 ha^{-1} was obtained from the treatment combination of Ca_2Zn_1followed by $Ca_3Zn_1$where the lowest gross return Tk.196200 ha^{-1} was found from the treatment combination of Ca_0Zn_0followed by Ca_1Zn_0.

Among the different treatment combinations Ca_2Zn_1 gave the highest net return Tk.275888 $ha^{-1}$and the 2nd highest net return (Tk. 250470 ha^{-1}) was done from Ca_3Zn_1 while the lowest net return Tk.95232 ha^{-1} was obtained from the treatment combination of Ca_0Zn_0.

The benefit cost ratio (BCR) was found to be the highest (3.69) in the treatment combination of Ca_2Zn_1. The lowest BCR (2.07) was recorded from the treatment combination of Ca_0Zn_0. Thus it was apparent that the 27 kg Ca ha^{-1} with 3.5 kg Zn ha^{-1} gave the highest green chilli yield (12.62 t ha^{-1}) and the highest gross return (Tk.378600 ha^{-1}).

Therefore, it may be suggested that though Ca_2Zn_1 gave the highest green chilli yield ha^{-1}, further studies in this relation should be conducted in other regions of the country before final recommendation.

Table 7.Combined effect of calcium and zinc on economic analysis of green chilli Production

Treatment	Cost of production	Gross return	Net return	BCR
Ca_0Zn_0	100968	196200	95232	1.94
Ca_0Zn_1	101622	270000	168378	2.66
Ca_0Zn_2	102058	217200	115142	2.13
Ca_1Zn_0	101840	211200	109360	2.07
Ca_1Zn_1	102494	306000	203506	2.99
Ca_1Zn_2	102930	275400	172470	2.68
Ca_2Zn_0	102058	261000	158942	2.56
Ca_2Zn_1	102712	378600	275888	3.69
Ca_2Zn_2	103148	285600	182452	2.77
Ca_3Zn_0	102276	238800	136524	2.33
Ca_3Zn_1	102930	353400	250470	3.43
Ca_3Zn_2	103366	333000	229634	3.22
Cost of green chilli = Tk. 30000 ton^{-1}				

Ca_0 = 0 kg ha^{-1}
Ca_1 = 19 kg ha^{-1}
Ca_2 = 27 kg ha^{-1}
Ca_3 = 35 kg ha^{-1}

Zn_0 = 0 kg ha^{-1}
Zn_1 = 2.5 kg ha^{-1}
Zn_2 = 5.0 kg ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November 2015 to March 2016 to study the influence of calcium and zinc on growth and yield of green chilli. The variety "BARI Morich 2" was used as experimental materials. The experiment consisted of two factors: Factor A: Ca application (4 levels) as; (i) Ca_0 = 0 kg ha^{-1}, (ii) Ca_1 = 19 kg ha^{-1}, (iii) Ca_2 = 27 kg ha^{-1} and (iv) Ca_3 = 35 kg ha^{-1} and Factor B: Zn application (3 levels) as; (i) Zn_0 = 0 kg ha^{-1}, (ii) Zn_1 = 2.5 kg ha^{-1} and (iii) Zn_2 = 5.0 kg ha^{-1}. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on growth, yield contributing characters and yields were recorded and statistically significant variation was observed for different treatment. Different levels of Ca application had significant variation on growth, yield contributing parameter and yield of green chilli.

Results showed that in terms of Ca effect, the highest plant height (5.03, 11.48, 24.62 and 34.17 cm at 20, 40, 60 DAT and at harvest respectively) and number of leaves $plant^{-1}$ (6.42, 33.93, 47.17 and 65.00 at 20, 40, 60 DAT and at harvest respectively) were recorded from Ca_3 (35 kg Ca ha^{-1}) where the lowest days to flower initiation (47.50 days) and days to first fruiting (50.20 days) were also recorded from Ca_3 (35 kg Ca ha^{-1}). Again, the highest number of branches $plant^{-1}$ (3.71, 10.00 and 11.88 at 40, 60 DAT and at harvest respectively) was found from Ca_2 (27 kg Ca ha^{-1}). The highest total dry mass $plant^{-1}$ (89.25 g), stem base diameter (1.32 cm), number of flowers $plant^{-1}$ (69.65), number of fruits $plant^{-1}$ (59.63), fruit length (6.70 cm), fruit diameter (0.97 cm), number of seeds $fruit^{-1}$ (72.60), 1000 seed weight (7.85 g), average fruit weight (2.66 g), fruit yield $plant^{-1}$ (243.80 g) and the highest fruit yield ha^{-1} (10.30 t) were also recorded from Ca_2 (27 kg Ca ha^{-1}). The shortest plant (3.84, 9.69, 21.98 and 30.84 cm at 20, 40, 60

DAT and at harvest respectively), minimum number of leaves plant^{-1} (4.98, 25.80, 33.07 and 46.00 at 20, 40, 60 DAT and at harvest respectively) and the lowest number of branches plant^{-1} (2.47, 7.52 and 7.94 at 40, 60 DAT and at harvest respectively) and highest days to flower initiation (52.83 days) and highest days to first fruiting (55.73 days) were found from control treatment, Ca_0 (0 kg Ca ha^{-1}). The lowest total dry mass plant^{-1} (70.58 g), stem base diameter (0.92 cm), number of flowers plant^{-1} (59.27), number of fruits plant^{-1} (49.07), fruit length (5.87 cm), fruit diameter (0.87 cm), number of seeds fruit^{-1} (59.00), 1000 seed weight (6.78 g), average fruit weight (1.71 g), fruit yield plant^{-1} (174.80 g) and the lowest fruit yield ha^{-1} (7.59 t) were also found from control treatment, Ca_0 (0 kg Ca ha^{-1}). The highest increased yield over control (57.19%) was observed from Ca_2 (27 kg Ca ha^{-1}) where the lowest yield increased over control (34.66%) was found from Ca_1 (19 kg Ca ha^{-1}).

In case of Zn effect, the tallest plant (5.24, 11.90, 24.69 and 35.03 cm at 20, 40, 60 DAT and at harvest respectively), highest number of leaves plant^{-1} (6.60, 34.85, 49.63 and 68.50 at 20, 40, 60 DAT and at harvest respectively) were obtained from Zn_2 (5.0 kg Zn ha^{-1}) but highest number of branches plant^{-1} (3.85, 10.65 and 12.34 at 40, 60 DAT and at harvest respectively) were obtained from Zn_1 (2.5 kg Zn ha^{-1}). The lowest days to flower initiation (46.80 days) and highest fruit diameter (1.01 cm) were recorded from Zn_2 (5.0 kg Zn ha^{-1}) but the lowest days to first fruiting (49.48 days) were obtained from Zn_1 (2.5 kg Zn ha^{-1}). The highest total dry mass plant^{-1} (92.61 g), stem base diameter (1.44 cm), number of flowers plant^{-1} (71.90), number of fruits plant^{-1} (62.18), fruit length (6.89 cm), number of seeds fruit^{-1} (76.30), 1000 seed weight (8.10 g), average fruit weight (2.84 g), fruit yield plant^{-1} (257.10 g) and the highest fruit yield ha^{-1} (10.90 t) were also recorded from Zn_1 (2.5 kg Zn ha^{-1}). The shortest plant (3.77, 9.61, 21.73 and 30.39 cm at 20, 40, 60 DAT and at harvest respectively), minimum number of leaves plant^{-1} (4.98, 25.48, 32.10 and 44.75 at 20, 40, 60 DAT and at harvest respectively) and lowest number of branches plant^{-1} (2.46, 7.51 and 8.19 at 40, 60 DAT and at harvest respectively) were found from control treatment, Zn_0 (0 kg Zn ha^{-1}). The lowest total dry mass plant^{-1} (68.63 g), stem base diameter (0.91 cm), days to flower initiation (52.58 days), number of flowers plant^{-1} (58.56), days to first fruiting (55.85 days), number of fruits plant^{-1} (48.48), fruit length (5.82 cm), fruit diameter (0.87 cm), number of seeds fruit^{-1} (57.80), 1000 seed weight (6.76 g), average fruit weight (1.71 g), fruit yield plant^{-1} (173.30 g) and fruit yield ha^{-1} (7.56 t) were recorded from Zn_0 (0 kg Zn ha^{-1}). The highest increased yield over control (66.77%) was found from Zn_1 (2.5 kg Zn ha^{-1}) where the lowest increased yield over control (41.59%) was found from Zn_2 (5.0 kg Zn ha^{-1}).

Considering combined effect of Ca and Zn, the tallest plant (5.79, 12.69, 26.13 and 36.37 cm at 20, 40, 60 DAT and at harvest respectively), maximum number of leaves plant^{-1} (7.10, 38.80, 56.00 and 75.00 at 20, 40, 60 DAT and at harvest respectively) and lowest days to flower initiation (44.60 days) were recorded from Ca_3Zn_2 where the highest fruit diameter (1.12 cm) was recorded from Ca_2Zn_2 and lowest days to first fruiting (47.50 days) was recorded from Ca_3Zn_1. But the highest number of branches plant^{-1} (4.12, 11.62 and 13.84 at 40, 60 DAT and at harvest respectively) was observed from Ca_2Zn_1. The highest total dry mass plant^{-1} (98.36 g), stem base diameter (1.67 cm), number of flowers plant^{-1} (76.60), number of fruits plant^{-1} (68.60), fruit length (7.24 cm), number of seeds fruit^{-1} (83.00), 1000 seed weight (8.52 g), average fruit weight (3.28 g), fruit yield plant^{-1} (280.20 g) and the highest fruit yield ha^{-1} (12.62 t) were also recorded from Ca_2Zn_1.On the contrary, the shortest plant (3.39, 8.89, 20.28 and 28.76 cm at 20, 40, 60 DAT and at harvest respectively), minimum number of leaves plant^{-1} (3.90, 22.20, 28.40 and 35.00 at 20, 40, 60 DAT and at harvest respectively), lowest number of branches plant^{-1} (1.43, 5.67 and 5.90 at 40, 60 DAT and at harvest respectively), lowest total dry mass plant^{-1} (57.16 g) and the lowest stem base diameter (0.77 cm) were observed in control treatment combination (Ca_0Zn_0)

where the highest days to flower initiation (56.30 days) and highest days to first fruiting (60.10 days) were observed from Ca_0Zn_0. The lowest number of flowers plant^{-1} (53.70), number of fruits plant^{-1} (44.30), fruit length (5.40 cm), fruit diameter (0.82 cm), number of seeds fruit^{-1} (51.70), 1000 seed weight (5.88 g), average fruit weight (1.32 g), fruit yield plant^{-1} (133.50 g) and lowest fruit yield ha^{-1} (6.54 t) were obtained from Ca_0Zn_0.The highest increased yield over control (92.97%) was found from Ca_2Zn_1 where the lowest increased yield over control (7.65%) was found from Ca_1Zn_0.

With a view to economic benefit, the highest gross return and net return; Tk. 378600 ha^{-1} and Tk. 275888 ha^{-1} respectively was obtained from the treatment combination of Ca_2Zn_1 where the lowest gross return and net return; Tk. 196200 ha^{-1} and Tk. 95232 ha^{-1} respectively was obtained from the treatment combination of Ca_0Zn_0. The highest BCR (3.69) was found from Ca_2Zn_1 where the lowest BCR (2.07) was recorded from Ca_0Zn_0.

From the above summary, it can be concluded that a higher yield can be achieved with Ca_2 @ 27 kg ha^{-1} with Zn_1 @ 2.5 kg ha^{-1}. In some cases, Ca_3 @ 35 kg ha^{-1} and Zn_2 @ 5.0 kg ha^{-1} gave better performance considering growth and yield contributing parameters but finally combination of Ca_2 @ 27 kg ha^{-1} with Zn_1 @ 2.5 kg ha^{-1} gave the best yield and highest net return with highest BCR.

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APPENDICES

Appendix I. Monthly recorded air temperature, relative humidity, rainfall and sunshine from November 2015 to February 2016

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)	Sunshine (Hours)
		Max.	Min.	Avg.			
2015	November	29.21	19.5	24.36	68.63	0	230.0
2015	December	24.32	15.4	19.86	70.76	0	192.6
2016	January	22.67	13.17	17.92	70.05	8.52	161.6
2016	February	26.56	17.49	22.03	72.25	20.60	219.9
2016	March	30.60	22.76	26.68	80.64	24.40	224.6

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. The mechanical and chemical characteristics of soil of the experimental site.

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
pH	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (µ gm/gm)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix III. Significant effect on plant height of chilli affected by calcium and zinc

Source of variation	Degrees of freedom	Mean square of plant height			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.320	0.891	1.951	1.042
Factor A	3	7.770*	9.40**	8.300*	10.684*
Factor B	2	10.162*	15.561*	16.039**	13.517*
AB	6	1.280**	3.033*	2.151*	4.613*
Error	22	0.117	0.241	2.267	3.372

** Significant at 1% level * Significant at 5% level

Appendix IV. Significant effect on number of leaves plant^{-1} of chilli affected by calcium and zinc

Source of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.364	1.422	1.053	1.003
Factor A	3	3.808**	9.098**	14.201*	15.261*
Factor B	2	7.125*	7.674*	16.265*	17.265*
AB	6	5.114*	7.898*	10.034**	8.031**
Error	22	1.167	2.781	2.921	3.804

** Significant at 1% level * Significant at 5% level

Appendix V. Significant effect on number of branches plant^{-1} of chilli as affected by calcium and zinc

Source of variation	Degrees of freedom	Mean square of number of branches plant^{-1}			
		20 DAS	40 DAS	60 DAS	At harvest
Replication	2	0.114	0.713	1.162	1.810
Factor A	3	1.291**	4.328**	8.565*	7.508*
Factor B	2	3.129*	6.143*	9.544*	8.608*
AB	6	1.478**	2.343*	3.126*	6.785*
Error	22	0.642	1.022	1.023	2.406

** Significant at 1% level * Significant at 5% level

Appendix VI. Significant effect on yield contributing parameters of chilli as affected by calcium and zinc

Source of variation	Degrees of freedom	Mean square of yield contributing parameters					
		Total dry mass $plant^{-1}$ (g)	Stem base diameter (cm)	Days to flower initiation	Number of flowers $plant^{-1}$	Days to first Fruiting	Number of fruits $plant^{-1}$
Replication	2	1.013	0.394	2.817	3.926	2.811	3.939
Factor A	3	4.565*	3.248*	16.043**	18.607**	12.033**	16.617**
Factor B	2	5.886**	2.762*	19.729*	14.614*	18.119*	12.604*
AB	6	2.324*	0.631*	14.644**	10.261*	8.638**	8.271*
Error	22	1.103	0.657	4.017	3.155	3.117	3.187

** Significant at 1% level * Significant at 5% level

Appendix VII. Significant effect on yield parameters of chilli as influenced by calcium and zinc

Source of variation	Degrees of freedom	Mean square of yield contributing parameters		
		Fruit yield $plant^{-1}$ (g)	Yield (t ha^{-1})	Yield increased over control (%)
Replication	2	1.193	0.695	2.037
Factor A	3	11.261*	8.258*	16.031**
Factor B	2	8.103*	9.362*	12.706*
AB	6	4.251*	3.232*	9.613**
Error	22	1.272	1.204	3.012

** Significant at 1% level * Significant at 5% level

Appendix VIII: Cost of production of chilli as influenced by calcium (Ca) and zinc (Zn)

A. Input cost

Treatment	Labour cost (Tk ha^{-1})	Ploughing cost (Tk ha^{-1})	Seed/seedling cost (Tk ha^{-1})	Irrigation cost (Tk ha^{-1})	Pesticide cost (Tk ha^{-1})	Weeding cost (Tk ha^{-1})	Manure and fertilizer cost (Tk ha^{-1})	Cost of Ca (Tk ha^{-1})	Cost of Zn (Tk ha^{-1})	Total input cost (A)
Ca_0Zn_0	10000	8000	1000	4000	3000	4000	17310	0	0	47310
Ca_0Zn_1	10000	8000	1000	4000	3000	4000	17310	0	600	47910
Ca_0Zn_2	10000	8000	1000	4000	3000	4000	17310	0	1000	48310
Ca_1Zn_0	10000	8000	1000	4000	3000	4000	17310	800	0	48110
Ca_1Zn_1	10000	8000	1000	4000	3000	4000	17310	800	600	48710
Ca_1Zn_2	10000	8000	1000	4000	3000	4000	17310	800	1000	49110
Ca_2Zn_0	10000	8000	1000	4000	3000	4000	17310	1000	0	48310
Ca_2Zn_1	10000	8000	1000	4000	3000	4000	17310	1000	600	48910
Ca_2Zn_2	10000	8000	1000	4000	3000	4000	17310	1000	1000	49310
Ca_3Zn_0	10000	8000	1000	4000	3000	4000	17310	1200	0	48510
Ca_3Zn_1	10000	8000	1000	4000	3000	4000	17310	1200	600	49110
Ca_3Zn_2	10000	8000	1000	4000	3000	4000	17310	1200	1000	49510

B. Overhead cost

Treatment	Land lease cost (8% of land cost for 6 months) [Tk. 5000 decimal^{-1}]	Miscellaneous cost @ 5% of the input cost (Tk ha^{-1})	Interest on running capital for 6 months @ 8% of cost/year (Tk ha^{-1})	Overhead cost Subtotal (B)	Total cost of production (Tk ha^{-1}) (A + B)	Yield (t ha^{-1})	Gross income (Tk ha^{-1})	Net return (Tk ha^{-1})	Benefit cost ratio (BCR)
Ca_0Zn_0	49400	2366	1892	53658	100968	6.54	196200	95232	1.94
Ca_0Zn_1	49400	2396	1916	53712	101622	9.00	270000	168378	2.66
Ca_0Zn_2	49400	2416	1932	53748	102058	7.24	217200	115142	2.13
Ca_1Zn_0	49400	2406	1924	53730	101840	7.04	211200	109360	2.07
Ca_1Zn_1	49400	2436	1948	53784	102494	10.20	306000	203506	2.99
Ca_1Zn_2	49400	2456	1964	53820	102930	9.18	275400	172470	2.68
Ca_2Zn_0	49400	2416	1932	53748	102058	8.70	261000	158942	2.56
Ca_2Zn_1	49400	2446	1956	53802	102712	12.62	378600	275888	3.69
Ca_2Zn_2	49400	2466	1972	53838	103148	9.52	285600	182452	2.77
Ca_3Zn_0	49400	2426	1940	53766	102276	7.96	238800	136524	2.33
Ca_3Zn_1	49400	2456	1964	53820	102930	11.78	353400	250470	3.43
Ca_3Zn_2	49400	2476	1980	53856	103366	11.10	333000	229634	3.22