INFLUENCE OF POLYTHENE MULCH AND FOLIAR APPLICATION OF CALCIUM ON GROWTH AND YIELD OF LETTUCE

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BY

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Dedicated

To

My Beloved Parents

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ABSTRACT

The experiment was conducted to study the Influence of plastic mulch and calcium on growth and yield of lettuce in the month duration of November 2013 to January 2014, at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The experiment consisted of two factors: Factor A: plastic mulch (three levels) as- M_0- No mulch, M_1: White polythene mulch, M_2: Black polythene mulch. Factor B: Calcium (four levels) as- Ca_0: 0, Ca_1: 300 ppm, Ca_2: 450 ppm, Ca_3: 600 ppm of calcium chloride. The two factors experiment was laid out in Randomized Complete Block Design with three replications. In case of mulching, the highest gross fresh yield (33.0 t/ha) was found from M_2, while the lowest gross fresh yield (17.0 t/ha) from M_0. For different levels of calcium, the highest gross fresh yield (28.0 t/ha) was recorded from Ca_3, while the lowest gross fresh yield (22.0 t/ha) from Ca_0. Due to interaction effect, the highest gross fresh yield (34.7 t/ha) was found from M_2Ca_3, whereas the lowest gross fresh yield (14.2 t/ha) from M_0Ca_0. The highest benefit cost ratio (3.07) was noted from the combination of M_2Ca_3 and the lowest (1.01) from M_0Ca_0. All the growth, yield and quality related characters were superior with M_2Ca_3 treatment while the plants grown without mulch and calcium resulted poor growth and yield. It is apparent that it was suitable for lettuce cultivation with plastic mulch and foliar application Calcium.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
et al.	And others
BBS	Bangladesh Bureau of Statistics
BARC	Bangladesh Agriculture and Research Council
SRDI	Soil Resource Development Institute
°C	Degree Celsius
DAS	Date After Sowing
etc	Et cetera
FAO	Food and Agriculture Organization
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
UNDP	United Nations Development Program

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CERTIFICATE

This is to certify that thesis entitled, ***"Influence of Polythene Mulch and Foliar Application of Calcium on Growth and Yield of Lettuce"****submitted to the,* ***Department of Horticulture****, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE IN HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***Nusrat Jahan Jui****, Registration No.: 09-03696 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information received during the course of this investigation has been duly acknowledged.

Dated: June, 2015
Dhaka, Bangladesh

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CHAPTER I
INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an important and most delicate leafy salad vegetable under the family Asteraceae is using for human diet worldwide. Most often lettuce grown for its leaves but sometimes for its stems and seeds having low caloric value but rich in varied nutritional content. Lettuce in general is a good source of chlorophyll, vitamins (B, C, K) and minerals (Ca, Fe, K) fiber and folate which facilitates colon peristalsis. It also contains significant amounts of lutein, beta-carotene, lycopene, alkaloids and zea-xanthin. It mainly grown in cool season of the year in tropical and sub-tropical countries including Bangladesh (Rahman *et al*.,1997). The position of lettuce is 26^{th} among 39 vegetables and and is fourth for its consumption. This crop is the most popular salad crop in the world because of used crude, its vitamins enter to human body without change. Lettuce grown in poor soil will be tough and bitter tasting and also warmer climates with shorter cold periods may find no head on lettuce crops. The edges of lettuce leaves may turn brown and die back without proper management technique. Lettuce seed has a germination rate of 99 percent at 77°F; the germination rate drops to 87 percent 86°F.

During crop growth a number of factors may affect vegetable quality and quantity. These include judicious fertilization, efficient use of residual soil moisture. Out of these, the role of mulches on lettuce is crucial because it is an effective cultural practice to ensure crop production. Mulching helps to maintain uniform temperature, controls weed and the draining of fertilizers, conserves soil moisture and improves irrigation efficiency (AVRDC, 1990 Lippert*et al.*,1964). Thus growers need to increase their production by adopting appropriate strategies and techniques which will lead to sufficient and reliable yields without depleting the natural resource. Different mulches may improve the soil temperature as they absorb solar radiation and thereby heat the soil (Anderson *et al.*, 1995). The quality transparency and color of mulch film have a significant impact on the soil temperature and thereby, on intermediate under black polythene and lowest when the ground was not mulched (Salokangas 1973, Nimah 2007). The degree on contact between the mulch and soil, often quantified as a thermal contact resistance, can affect greatly the performance of mulch. If an air space is created between the plastic mulch and the soil by a rough soil surface, soil warming can be less effective than would be expected from particular mulch. Mulching has been shown to affect soil temperature, moisture level (Mahrer*et al.* 1984; Hatt*et al.* 1994) and bulk density (Liptay and Tiessen, 1970). Extensive research utilizing certain photo selective mulch has been reported to increase yields of various horticultural crops (Lamount, 2004). The best cucumber growth and highest yield were obtained by using black polythene mulch (Ibarra-Jimenez et al., 2008). Consequently, a mulch with a side highly reflective to solar radiation such as a coextruded white/black plastic mulch, might be better adapted to the need of this crop.

Calcium is providing to have a significant impact on the growth and yield of various vegetables. Calcium can serve as a source of Calcium ion in a solution, is another factor which plays a vital role to maintain growth, yield and quality of lettuce as it is soluble. The most effective method is foliar supplementation of this element. Pre-harvest application of Calcium increases the Calcium content, thus improving their nutritional value and growth (Poovaiah, 1986, Conway *et al.,* 1994). The marketing of minimally processed fruits and vegetables is limited by a short shelf life and rapid deterioration of their components due to tissue damage as a result of processing. Van Rensburg and Engelbrecht (1986) studied the effect of calcium salts on susceptibility to browning of avocados. Kim and Klieber 1997) reported that calcium reduce browning in minimally processed Chinese cabbage. Leaf Ca deficiency in tomato reduces leaf size and causes necrosis of young leaves and yield loss in extreme cases (Adams and Gizaway, 1988; Adams and Holder, 1992; Holder and Cockshull, 1990). Low supply of Ca to tomato leads blossom end rot (Ho *et al.,* 1999) which reduces its shelf life (Janse 1988). Different calcium salts have been studied for nutritional enrichment of fresh fruits and vegetables. Wills and Mahendra (1989) examined the effect of calcium on fresh-cut peaches from a quality point of view, meanwhile Conway and Sams (1984) evaluated the safety of strawberries treated with calcium. Other fruits and vegetables, in which the effect of calcium was studied, showing significant improvement in the growth and quality of the final product, are grapefruit (Baker, 1993).

Considering the above factors, the present experiment was undertaken to study the following objectives.

- To find out the effect of polythene mulch on growth and yield of lettuce
- To find out the effect of foliar application of calcium on growth and yield of lettuce
- To find out the interaction effect of polythene mulch and foliar application of calcium on growth and yield of lettuce

CHAPTER II
REVIEW OF LITERATURE

Very few studies on the growth and yield of lettuce have been conducted in our country. Consequently, the research work so far done in Bangladesh is not sufficient and conclusive. Nevertheless, some of the important informative works and research findings related to polythene mulch and foliar calcium application on lettuce so far been done at home and abroad have been reviewed in this chapter under the following headings.

2.1 Effect of mulch:

M. Ashrafuzzaman, *et al.* (2011) investigated a field study to evaluate the effect of colored plastic mulch on growth and yield of chilli from October 2005 to April 2006. The plastic mulches were transparent, blue, and black and bare soil was the control. Different mulches generated higher soil temperature and soil moisture under mulch over the control. Transparent and blue plastic mulches encouraged weed population which were suppressed under black plastic. Plant height, number of primary branches, stem base diameter, number of leaves and yield were better for the plants on plastic. At the mature green stage, fruits had the highest vitamin-C content on the black plastic. They found mulching produced the fruits with the highest chlorophyll-a, chlorophyll-b and total chlorophyll contents and also increased the number of fruits per plant and yield. Results of the study also showed that plants on black plastic mulch had the maximum number of fruits and highest yield. They concluded that mulching appears to be a viable tool to increase the chilli production under tropical conditions.

Piotr Siwek *et al.* (2007) conducted an experiment at the Experimental Station at Mydlniki by Krakow concerned the effect of mulching films of different colours made from original and recycled materials on microclimatic conditions and subsequent yield of ‘Melodion’ butter lettuce and ‘Tango’ celery. The objects of their experiment were polyethylene transparent, white and black films, made from original and recycled materials. Plants cultivated without mulching were the control. In lettuce cultivation on transparent mulch the temperature was by 2.4°C higher and in the case of celery by 1.7°C than the temperature of non-mulched soil. Under white and black film, the difference of temperature did not exceed

1.0°C. From the research result they concluded black mulches had most positive effect on the yield of both vegetables, followed by white and transparent films.

Parmar H. N. *et al.* (2013) carried out a study on watermelon (*Citrullus lanatus* Thunb) cv. Kiran at Fruit Research Station, “Lalbaugh”, Department of Horticulture, College of Agriculture, J.A.U., to study the effect of different mulching material on growth, yield and quality of water melon cv. Kiran. All the plant growth, yield and quality characters were superior with silver on black polyethylene mulch while, plants without mulch (control) resulted poor growth and yield. With economic point of view, silver on black mulch resulted in the highest net return and found to be more economical with highest cost: benefit ratio.

Water use efficiency in agriculture can be enhanced by several strategies mainly by reducing evaporation from the soil surface. The mulching techniques were being used widely in irrigated crop production worldwide was suggested by Atif Y Mahadeen (2014). His study aimed at evaluating the effect of polyethylene black plastic mulch on growth and yield of okra (*Abelmoschus esculentus)* and summer squash (*Cucurbita pepo* L.). under rain-fed conditions of Jordan. He applied two field experiments during summer growing season at Al-Rabbah Agricultural Research Station, Mu’tah University, Jordan. Soil cover treatments were polyethylene black plastic mulch and no mulch (bare soil). He shown his results which indicated that the mulched plots had higher soil moisture content than bare soil plots, which has positively reflected on vegetative and yield parameters. Using polyethylene plastic mulch had pronounced positive effect on yield of okra and squash as compared to bare soil. Early, middle, late and total yield of both vegetable crops were significantly increased in plots covered with plastic mulch. In addition, fruit number and weight had also an increasing trend as fruit yield. Plots covered with black plastic mulch were produced higher fresh and dry weights of both vegetable crops. He concluded that using black plastic mulch as a soil cover increased okra and squash vegetative growth and yield under rain-fed conditions.

Iraj khazaei *et al.* (2013) conducted a field experiment in Karaj-Iran to find out the effects of mulch, spacing and organic fertilizer on the growth and yield of lettuce. They applied two cultivation systems(mulch and no mulch), four levels of spacing (40×40 cm, 40×35 cm, 40×30 cm and 40×25 cm), and two different types of organic fertilizers (humic acid and vita mint). The treatments were set up in a split plot factorial design based on the randomized complete block design with three replications. According to their result mulching had significant effects on stem length, stem diameter, stem weight, head diameter, leaf number, bud number, stem fresh weight, stem dry matter and total yield. Also stem length, stem diameter, stem weight, bud number, leaf dry weight and K% were significantly affected by organic fertilizer. The highest total yield of lettuce was obtained from spacing 40×35 cm and the lowest observed in spacing 40×40. Although vita mint showed better effect on lettuce growth, organic fertilizer hadn't significant effect on total yield. Finally they found, total yield increased with mulch application compare with no mulch treatment.

Moses Mutetwa *et al.* (2014) investigated the effect of trash grass and sawdust mulches in combination with organic and inorganic fertilizers on onion growth and yield. They observed that mulching improved soil water retention capacity, improved soil structure and suppressed weeds. These features played a significant role in the performance and ultimately the yield of onions. Their work also sought to evaluate mulching materials and fertilizer types on the various components of the onion plant at different stages of development and hence their contribution to the final yield. Trash grass in combination with organic and inorganic fertilizer the final yield improved by 160% and 310% respectively. As for total plant weight, aerial leaf weight, bulb weight and yields plot were also higher with trash grass mulch. The effect of fertilizer types alone on the growth and yield of onions was less dramatic than that of mulch.

An experiment evaluated by Piotr Siwek, *et. al.,* (2007) at Mydlniki by Krakow concerned the effect of mulching films of different colors made from original and recycled materials on microclimatic conditions and subsequent yield of 'Melodion' butter lettuce and 'Tango' celery. They used polyethylene transparent, white and black films, made from original and recycled materials. Plants cultivated without mulching were the control. In lettuce cultivation on transparent mulch the temperature was by 2.4°C higher and in the case of celery by 1.7°C than the temperature of non-mulched soil. They found in case of white and black film, the difference of temperature did not exceed 1.0°C. Their research final result was concerned for; black mulches had most positive effect on the yield of both vegetables.

Md. Asaduzzaman, *et al.* (2010) examined the combined effect of mulch materials and organic manure on the growth and yield of lettuce in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2009 to January 2010 to find out the four levels of mulch materials viz. M = No mulching, M = Dry water hyacinth, M = Black polythene and M = Dry rice straw and four levels of o1 2 3 organic manure viz. OM = no organic manure, OM = Cow dung (20 t ha), OM = Poultry manure (10 t ha) o1 2 1 1 and OM = Vermicompost (10 t/ha) effect on growth and yield of lettuce. They observed that most of the growth parameters were influenced by the mulch materials and organic manure. All the parameters viz. number of leaves plant, leaf length (cm), leaf breath (cm), dry matter accumulation (%), yield (g/plant) and 11 yield (t/ha) performed better in case of Black polythene + vermicompost: 10 t ha, while the minimum growth and yield parameter were obtained from control at each observation stage.

Hamid Reza Rajablariani, *et al.* (2012) reported that tomato (*Lycopersicon esculentum* L.) was grown on polyethylene mulch films and bare soil for evaluating the effect of colored plastic mulches on weed and crop yield. The plastic mulches were blue, black, clear, red and silver on black. Black and silver/black plastic mulches suppressed weeds which were encouraged under clear, blue and red mulches. Their findings indicated that soil temperature increased under the various colored plastic mulches about 3 to 6 ˚C more than it in bare soil. Number of branches and leaves were better for the plants grown over plastic compared to bare soil. The highest early yield was obtained in clear plastic likely due to light entrance and raising soil temperature. Mulching increased marketable yield relative to bare soil as the plants grown on silver/black plastic mulch indicated a 65% increasing in marketable mulch compared to control treatment.

M Moniruzzaman (2006) conducted an experiment with three levels of spacing (40 x 20 cm, 40 x 30 cm and 40 x 40 cm) and two levels of mulching (mulch and non-mulch) to find out the effect of plant spacing and mulching on yield and profitability of lettuce cv. Green Wave at the Agricultural Research Station, Raikhali, Rangamati. He found that plant spacing, mulching and their interaction showed significant effect on yield and yield components of lettuce. Significantly higher fresh yield of lettuce was obtained from the mulched plants than that of un-mulched plants. The highest yield (25.9 t/ha in 1999-'00 and 28.3 t/ha in 2000-'01 with an average of 27.10 t/ha) was observed in the spacing of 40 x 20 cm with mulch, which was statistically at par with the spacing of 40 x 30 cm with mulch. His results also revealed that higher Gross Return (Tk. 216, 800.00) was obtained from the closest spacing in combination with mulch followed by medium spacing (40 x 30 cm) with mulch (Tk. 210, 160.00). The treatment combination of 40 x 30 cm spacing and mulching gave the highest benefit cost ratio (8.84).

Garry G. Gordon*et al.* (2010) carried out an experiment concerned on Okra (*Abelmoschus esculentus* 'Clemson Spineless') was grown on an Orangeburg sandy loam soil in Shorter; AL. Okra was direct-seeded in single rows. Treatments consisted of five mulch colors: black, white, red, silver, and blue installed either with or without spun-bonded row cover. Soil temperatures were 4 to 7 °C lower than air temperatures in all treatments. The use of darker (black, blue, red) -colored plastic mulches increased early and total yield of okra compared with bare soil with and without row cover. Increased soil and air temperatures did not always correlate to an increase in yield. It can be concluded that the use of dark plastic mulch is advantageous to growers of okra in climates that do not have cool springs, but the added use of row covers to plastic mulch has no effect on growth and yield.

According to Toshio Hanada (1991) plastic mulches have various beneficial effects on crop product in temperate regions, including an increase in soil temperature; the conservation of soil moisture, texture and fertility; and the control of weeds, pests and diseases. He also reported that mulching with fresh leaves gave better yields than plastic films in summer in the subtropics, since plastic mulching produced a marked increase in soil temperature. And his final result was the increase of yield for the combined result of row covers, using plastic nets and non-woven fabrics. Shading, suppression of soil temperature increase, conservation of soil moisture, and protection from wind and pestsalso increased the yield of vegetables, especially that of leafy vegetables, in the tropics and the subtropics.

Adetunji (1990) carried out an experiment to optimize the utilization of irrigation water and sawdust, millet stover and groundnut shell mulches for dry season lettuce production in the semi-arid region; Three irrigation frequencies (3, 7 and 11 day intervals) and for mulching sawdust, millet stover and groundnut shell were applied. From his findings he concluded that growth and yield attributes of lettuce were significantly higher under groundnut shell and millet stover mulches than in sawdust mulch and control. Because mulching reduced the day time temperature and conserved soil moisture content. Soil temperature above 25°C is deleterious to the normal growth and yield of lettuce and lettuce requires a soil moisture content corresponding to at least 60 % plant available water in the 12 cm of soil for optimum yield and this can be provided with about half of the amount of water with mulching than without mulching.

Melek Ekinci *et al.* (2009) investigated an experiment to determine the effects of different mulch materials on plant growth, some quality properties and yield in melon cultivars in high altitude environmental condition. He found clear mulch application affected more plant growth than the other applications. Average fruit weight of the cultivars was significantly high in mulch application, especially clear mulch application when compared to control. The highest marketable yield was obtained from clear mulch application as compared to control. The effects of mulch application in terms of the characters were significant depending on the cultivars. Average marketable yield in the study years increased by 25-28% in clear plastic mulch and 15% in black plastic mulch compared to the control application. Soil temperature in clear and black mulch applications were higher (5-8^0 C and 1-4^0 C respectively) than that of control application.

Edyta Kosterna (2015) reported that plastic covers influenced the growth and development and increased the yield of vegetables in his study which was investigated to determine the effect of plant covering and the type of straw applied to soil mulching (rye, corn, rape or buckwheat) on the soil temperature, development of the plant and the yield of ‘Polfast’ F1 tomato. Soil mulching with organic material is one method of soil water protection and also helps maintain a constant soil temperature within the root system of crops. The increase in soil temperature as a result of covering amounted to 1.3°C at 8:00 a.m. and 1.7°C at 2:00

p.m. Both in the morning and in the afternoon, the soil temperature in the plots without straw and without covers and under polypropylene fiber was higher than in the plots with straw. He found application of covers resulted in higher above ground parts of plants and higher leaf area compared to cultivation without covers. Irrespective of whether a covering was used, all of the types of straw investigated in the experiment caused the acceleration of growth and development of tomato plants. Simultaneous plant covering and soil mulching increased the total yield of fruits.

According to Coates Beckford *et al.* (1997) growth and yield of three crops of cucumber and rhizosphere populations of soil nematodes were monitored in an experiment conducted on sandy loam soil which was (a) mulched with 0.4-mm-thick, clear or black plastic for five or nine weeks, (b) mulched then fertilized with 1 kg N:P:K (4:16:4)/plot, (c) not mulched and treated with 45 g Banrot 40WP/plot or 10 or 20 g Furadan 10G/plot at planting, (d) not mulched, but fertilized, (e) not mulched and not fertilized. In a second experiment, plots were mulched for four, six and eight weeks with clear or black plastic or not mulched. Ambient and soil temperatures were monitored during the mulching periods. They finally concluded that Cucumber seedlings in the fertilized or non fertilized plots which were mulched with either color of plastic often grew faster than those in the non-mulched plots.

I. A. Hudua *et al.* (2008) carried out a field experiment in cool dry seasons to determine the effect of grass mulching intensities on soil temperature, weed infestation and growth and yield of irrigated tomato at Maiduguri in the semi-arid zone of Nigeria. In these trials, soil temperature difference between 0700 hours and 1300 hours was two times lower in mulched treatments than un-mulched control treatment, thus keeping the day time soil temperature below supra-optimum levels. Furthermore, they found plant height, number of flowers/plant, fruit sets/plant, number of fruits/plant and harvested total marketable fruit yield/ha were significantly higher in the mulched treated plots than the un-mulched control treatment. They also observed, that the optimum mulch thickness of grass material in this area in terms of effective weed suppression, better crop growth, optimum root temperatures and ultimate high yield of tomato.

Maria Victoria Aguero *et al.* (2008) investigated that different soil management in crop cultivation plastic mulch or bare soil are like to influence microflora behavior during the post harvest of the product. The evolution of native microflora and sensory quality analysis were assayed during cold storage from butter lettuce (*Lactuca Sativa* Var. Lores) from green house cultivation using mulch and bare soil. The lettuce cultivation method had impact on the initial counts as well as on microbial evolution during refrigerated storage, playing a singular role on the sensorial quality and shelf life of each lettuce. The higher initial counts in mulch lettuce could be explained by the microclimate generated by the plastic mulch around the plant. While bacterial increment was observed from the beginning of the storage of three zones of bare soil lettuce, cold storage had a bacteriostatic and bactericidal effect on mulch lettuce. They found through OVQ indexes a significant higher shelf life was observed on mulch lettuce.

Hosea D. Mtui, *et al.* (2014) conducted a field experiment in Tanzania, to determine the effect of mulch on shelf life of tomato. 'Tanya VF' and 'Tengeru 97' tomato varieties were used in this study. Field experiment consisting of a 2×2×4 factorial arrangement in a split-split plot design with three replications was conducted. Treatment factors comprised two varieties (main plot factor), mulching (subplot factor) and three fungicide spray regimes (sub subplot factor). The laboratory experimental layout was a CRD with three replications. The laboratory had a max/min temperature of 31^0 /19^0C. Shelf life assessment was done weekly for six weeks. They found that the use of mulch led to fruits with consistently longer shelf life for four weeks in storage ($p = 0.001$, $p = 0.008$, $p < 0.001$, $p = 0.037$, respectively). Considering the two varieties, 'Tengeru 97' consistently had lower ($p < 0.001$) fruit loss throughout the storage duration compared to 'Tanya VF'. It was also revealed that, harvesting at different maturity stages had significant influence ($p < 0.001$) on fruit shelf life.

R. Kumara *et al.* (2014) reported that use of leaf mulch as a soil cover is effective in improving yield and soil fertility in their field experiment was conducted during 2010 and 2011 to study the effect of plant spacing (30 cm × 30 cm and 45 cm × 30 cm) and four mulches pine needles (*Pinusrox burghii*), poplar leaf (*Populus deltoides*), silver oak (*Grevillea robusta*) tree leaf mulch and unmulched control} on growth, yield, quality of stevia and soil fertility. They found dry leaf yield, total dry biomass and leaf area index (LAI) were significantly higher in 30 cm × 30 cm spacing level and poplar leaf mulch. All the mulched plots significantly increased organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K), bacterial and fungal population compared to un-mulched plots. Rebaudioside-A content was higher in plots mulched with leaves. Steviol glycosides were not significantly affected by different treatments. Soil biological activities were also enhanced by tree leaf mulches. Leaf mulch enhanced microbial biomass, relative to non-mulched soils.

Walsh *et al.* (1996) carried out trials in which a straw mulch was applied in an apple orchard, and found that nitrate ($NO3^-$) levels in the top soil were higher in the mulch treatment than in the control (grass cover), and in a composted manure mulch. However, the nitrate level decreased as the straw mulch decomposed over the season, thus reducing the amount of N leaching. This also ensured that the hardening off of the trees was not affected by high N levels. Potassium levels were higher under the straw mulch than under inorganic geotextile mulch, but the straw mulch had no effect on Ca and Mg levels. The higher nutrient levels in trees to which organic mulches were applied is partially due to the higher soil moisture and increase in root growth (Acharya and Sharma 1994). The spreading of roots through a larger soil volume increases the potential absorption of relatively immobile elements such as P and K, which may lead to an increase in yield (Acharya and Sharma 1994)

2.2 Effect of Calcium:

Abou El Hassan, *et al.* (2015) conducted an experiment to determine the effect of humic, fulvic acid and calcium foliar application on growth, yield and fruits quality of tomato plants. The experimental design was completely randomized block design with three replications at the Agricultural Experimental Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The tomato transplants, ‘H9663’ cultivar, were grown on clay soil during the 2013 and 2014 seasons. The individual and combination applications of humic acid (0.4 %), fulvic acid (4%) and chelated calcium (0.25 %) solutions were applied as foliar sprays on tomato plants at four times (after two, four, six and eight weeks from transplanting). Growth and nutrients content (N, P, K and Ca) of tomato plants as well as yield and fruits quality were investigated in treated and untreated plants. Results indicated that all foliar applications of humic, fulvic acid and calcium, either individual or in combinations, increased vegetative growth, yield and fruit quality. They concluded application of humic, fulvic acid and calcium as foliar application improved the plant growth, yield and fruits quality of tomato.

Mohsen Kazemi (2014) carried out a study to evaluate the effects of foliar application of humic acid and calcium chloride on vegetative and reproductive growth, yield, and quality of tomato plants as a completely randomized block design with 4 replications. He applied humic acid (15 and 30 ppm) and calcium chloride (10 and 15 mM) solutions as foliar sprays either alone or in combination. He recorded data for plant height, branches per plant, flowers per cluster, fruits per plant, yield, fruit weight, fruit firmness and total soluble solid content of the fruit. His findings showed that humic acid (30ppm) and calcium chloride (15 mM) spray either alone or in combination (30 ppm HA+15 mM Ca) affected on vegetative and reproductive growth and chlorophyll content, significantly. Finally, he concluded that humic acid and calcium chloride application can be helpful for yield improvement and prevent of decreasing yield.

Abdul Ahad Qureshi, *et al.* (2012) reported calcium carbide (CaC2) has proved to be a good source of acetylene (nitrification inhibitor) and ethylene (plant hormone). An experiment they conducted to evaluate the effects of encapsulated calcium carbide (ECC) on the growth, yield and tuber quality of potato. ECC was applied @ 60 kg/ha for each treatment except control at different growth stages of potato (sprout development, vegetative growth, tuber initiation, tuber bulking) and their combinations. The results of their work revealed significant effects of ECC application on number of days to sprouting, number of leaves and stems, plant height, tuber size, yield, weight loss %, shrivillage % and reducing sugars of potato while sprouting percentage, disease incidence %, specific gravity, TSS, total starch, non-reducing sugars and total sugars could not demonstrate significant effects of ECC application. Moreover, they concluded that different growth stages responded differently against ECC, however, vegetative growth stage showed remarkable effects on potato growth, yield and tuber quality compared to all other stages and their combinations. The enhanced growth, yield and quality of potato indicated the possible role of acetylene and ethylene at active growth stages.

N. Nasrollahzadeh-asl, *et al.* investigated an experiment which was aimed to evaluate the effect of foliar application on greenhouse cucumber (cv. Khassib) in a five-month period (from March 2007 to July 2008) in Karaj city, Iran to achieve the yield and high quality products. For this reason they conducted the experiment based on split-split-plot design with three replications. The effects of urea fertilizer concentration (3 g/L), calcium nitrate concentration (10 g/L) and boric acid concentration (0.5 g/L) on quality and quantity of greenhouse cucumber, including fruit yield, yield of grade 1 fruit, number of fruit, percentage of grade 1 fruit, plant length, percentage of leaf dray matter, and leaf weight ratio (LWR). Their results indicated that among the main effects, treatment calcium nitrate had the most influence on the large number of traits. Also, among two-way interactions, treatment U1B1 induced the most effect on yield of grade 1 fruit as well as for three-way interaction, only treatment U1C0B0 induced the most influence on the yield of total fruit, yield of grade 1 fruit and number of fruit.

Alireza, *et al.* (2012) evaluated an experiment to investigate the effect of calcium and potassium application on yield and yield components of peanut (*Arachis hypogaea* L.) in 2009 was conducted in factorial arrangement as a randomized complete block design with three replications in kyashahr port located at the eastern of Guilan, Iran. Two factors were used in this study including potassium rates in 4 levels (0, 30, 60 and 90 kg/h from potassium sulfate) and calcium rates in 4 levels (0, 30, 60 and 90 kg/h from gypsum). Their findings showed that the application of calcium had significant effect on pod yield, kernel yield and oil content, So that applying of 90 kg/h calcium form gypsum 1 performed considerably better than the rest. But applying of these fertilizers had no significant effect on protein content of peanut kernel. The yield of pod and kernel also increased with increasing of calcium application along with potassium. The highest yield of pod (5650 kg/h) and kernel (4622 kg/h) were obtained from 90 kg calcium form gypsum. The highest oil content (46.22%) was obtained in 90 kg calcium and 30 kg potassium (interaction effect). According to the results of their study it could be said that the efficient application of fertilizers, especially potassium along with essential elements such as calcium and sulfur is an important factor for increasing of growth and yield of peanut. Therefore, consideration of suitable proportion of calcium and potassium can have acceptable yield of peanut.

Abbas Al-Hamzawi, *et al.* (2010) carried out a study which was conducted during the period of December 2008 to May 2009 using cucumber (*Cucumis sativus* L. cv. Al-Hythum). Three concentrations of Anfaton; 0.00, 600 and 1000 mg L¯1 and five concentrations of spray solutions; 0.00 mM (control), 10 and 15 mM of Ca(NO3)2 and 10 and 15 mM of KNO3 in addition to the combination of anfaton and the two nutrients were used in their experiment. Their results revealed that the. Ca(NO3)2 treatments produced the least weight loss compare to KNO3 treatments. Potassium nitrate at both concentrations was the best in keeping the Total Soluble Solid (TSS) at higher levels. Also, all nutrients treatments reduced electrolyte leakage from fruits compare to control especially the Ca(NO3)2 treatments.

Rezaul Kabir, *et al.* (2013) conducted an experiment to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7. They used fertilizer doses of P (P0=0, P1= 25 and P2=50 kg ha-1), Ca (Ca_0=0, Ca_1=110 and Ca_2= 165 kg Ca ha-1) and B (0, 2 and 2.5 kg ha-1). Their experimental results showed among the growth parameters plant height, number of branches plant^{-1}, dry weight plant^{-1}, LAI and CGR were highest at 100 DAS in $P_2 \times Ca_2 \times B_2$ treatment combination. Among the yield attributing characters number of total pods plant-1 was highest for $P_1 \times Ca_2 \times B_2$, 100 pod weight plant -1 for $P_1 \times Ca_2 \times B_1$, shelling percentage, pod yield, biological yield, straw yield and harvest index for $P_2 \times Ca_1 \times B_2$. The lowest values of all these parameters were found at control treatment. The combined dose of P_2, Ca_1 and B_2 produced the highest values for almost all the above parameters. Finally they concluded that the fertilizer level for P, Ca and B should be 50 kg ha^{-1}, 110 kg ha^{-1} and 2.5 kg ha^{-1}, respectively for obtaining the highest yield of groundnut under this particular soil.

Mohsen Kazemi (2013) assessed the effect of calcium chloride and paclobutrazol foliar application on growth, yield and yield components of cucumber plants as a completely randomized experimental design with six replications. These factors included paclobutrazol in 3 levels (2.5, 5 and 10 mg/ L) and calcium chloride in 2 levels (7.5 and 15 mM) spray on cucumber. His findings indicated that paclobutrazol reduced vegetative growth by reducing both plant height and dry weights while simultaneously some such fruit length, fruit diameter, fruit weight and yield were increased. Paclobutrazol combined with potassium nitrate (10 mg/ L paclobutrazol +7.5 mM calcium chloride) had positive effects on fruit quality. Calcium chloride alone had effect on photosynthetic pigments and minerals. Finally he concluded the application of calcium chloride and paclobutrazol in low concentration improved the yield contributing factors that resulted in significant increase in cucumber fruit yield.

M. J. Hutchinson, *et al.* (2006) examined the effects of various levels of farmyard manure and calcium ammonium nitrate (CAN) on vegetative growth, yield and quality (vitamins A and C and nitrates) of Cleome gynandra in Keiyo District, during long and short rains of the year 2002. Their experimental layout was a RCBD with four replicates. The treatments were four levels of farmyard manure (FYM; 5, 10, 15, 20 t/ha) and four rates of CAN (100, 200, 300, 400 kg/ha). The addition of various rates of FYM and CAN that were tested significantly improved vegetative growth and increased leaf yields of Cleome gynandra. Their results showed plants grown with FYM were generally higher than from those with CAN. The incorporation of either FYM or CAN increased vitamin A content in both seasons. During Season 1, FYM increased vitamin C content in both young and older tissues, while CAN had no effect on the same. The application of 300 kg/ha of CAN increased the accumulation of nitrates in young and old tissues, while FYM had no effect on the same. They found fertilizer type and rate of application, season, plant age and management had a significant influence on vegetative growth, leaf yield and quality of Cleome gynandra.

M. Ataur Rahman (2006) carried out a study for determining the effect of fertilizer element calcium and Brady rhizobium inoculation in improving the yield and quality of groundnut seed. His experiment was conducted in 1997-78 and 1998-99 in the clay loam soil. The fertilizing element calcium significantly affected all the yield attributes and quality up to 150kg/ha and then decline. There was also an increasing trend in qualitative characteristics like percentage of oil and protein content of groundnut with the increase in the level of calcium from 0-150 kg/ha. He found fertilizer element calcium and Brady rhizobium fertilization affected the yield significantly but most of the yield attributes was not affected significantly.

Mammucari R. *et al.* (2011) carried out a study to investigate the effect of calcium on growth, survival, essential oil yield and chemical compositions of vetiver grass grown on lead contaminated soils. Calcium inform of $CaCO_3$ (0, 2000, 4000, 6000 mg Ca kg (-1) was added to river sand soils containing 4000 mg Pb kg (-1) dry soil. Results showed that, in the absence of calcium treatment, no plants survived after 2 weeks of cultivation, while the rest grew well to the end of the experimental period (42 weeks). Calcium treatments generally resulted in a slight decrease in biomass. Interestingly, an increase in calcium over 2000 mg/kg did not result in a decrease in accumulation of lead in vetiver roots and shoots. The levels of lead in roots and shoots under calcium treatments were around 2000 and 90 mg/kg dry weight, respectively. The addition of $CaCO_3$ did not improve vetiver essential oil yield and chemical composition compared to the control. A level of applied $CaCO_3$ about half of the lead concentration in soils was sufficient to improve vetiver growth and survival.

Sunghun Park, *et al.* (2005) demonstrated that fruit from tomato (*Lycopersicon esculentum*) plants expressing Arabidopsis (Arabidopsis thaliana) H+/cation exchangers (CAX) have more calcium (Ca2+) and prolonged shelf life when compared to controls. Previously, using the prototypical CAX1, it has been demonstrated that, in yeast (Saccharomyces cerevisiae) cells, CAX transporters are activated when the N-terminal autoinhibitory region is deleted, to give an N-terminally truncated CAX (sCAX), or altered through specific manipulations. To continue to understand the diversity of CAX function, we used yeast assays to characterize the putative transport properties of CAX4 and N-terminal variants of CAX4. CAX4 variants can suppress the Ca2+ hypersensitive yeast phenotypes and also appear to be more specific Ca2+ transporters than sCAX1. Then they compared the phenotypes of sCAX1- and CAX4-expressing tomato lines. The sCAX1-expressing tomato lines demonstrate increased vacuolar H+/Ca2+ transport, when measured in root tissue, elevated fruit Ca2+ level, and prolonged shelf life but have severe alterations in plant development and morphology. The CAX4-expressing plants demonstrate more modest increases in Ca2+ levels and shelf life but no deleterious effects on plant growth. Their findings suggest that CAX expression may fortify plants with Ca2+ and may serve as an alternative to the application of $CaCl_2$ used to extend the shelf life of numerous agriculturally important commodities.

Dhruba R. *et al.* (2006) conducted an experiment in Institute of Agriculture and Animal Science, Rampur, Chitwan during 2003 to find out the effect of harvesting method and calcium chloride treatment on post- harvest physiology of tomato. Tomato (Hybrid Gootya) fruits with stalk and without stalk were harvested at breaker stage and dipped in distilled water and different concentrations of calcium chloride viz. 0.25%, 0.50%, 0.75% and 1% for fifteen minutes. Fruit were then air-dried and stored at ambient condition (24 ± 3 0 C and 70 ± 5 % RH). Among the tested treatments the least cumulative physiological weight loss (12.14%) was exhibited by 1% calcium chloride. They found the shelf life of tomato fruits was significantly affected by harvesting method and calcium treatment. Tomato fruit harvested with stalk had higher shelf-life (15 days) as compared to those harvested without stalk (12.93 days) irrespective to calcium chloride application. The maximum shelf life was noticed in 1% calcium chloride treated fruits (16.50 days) followed by 0.75% calcium chloride treated fruits (16.17 days).

Phillip Brannen, *et al.* (2008) reported that the impacts of several calcium formulations applied throughout the peach fruit development and growth period. Calcium nitrate, calcium chloride, or a calcium amino acid chelate (Metalosate® Calcium), were assessed for their effect on the quality and shelf life of peach fruit. Their findings concluded that the improvements in fruit firmness, peel growth cracking, and reduced post-harvest fruit rots and Calcium caused increased fruit size.

DeLong (1936) searched his research into the effect of calcium on fruit and vegetable quality was concerned with calcium's association with physiological disorders Subsequently, more than 30 calcium related disorders in various crops have been identified. It has been established that the disorders of storage organs of fruits and vegetable appear closely related to low calcium content in tissues.

Sylvestre Habimana, *et al.,* (2014) Studied on ripening, shelf-life, physico-chemical parameters and organoleptic evaluation of mango fruits (*Mangifera indica* L.) Cv. Alphonso which were carried out at the “A” block of mango orchard at UAS, GKVK Campus, Bangalore, Karnataka, India with the fallowing objectives: to evaluate the different concentrations of calcium chloride on ripening of certain varieties of mango; to study the effect of calcium chloride spray on shelf-life of different varieties of mango; to study the effect of calcium chloride spray on physico-chemical properties of mango and to study the effect of calcium chloride spray on organoleptic qualities of mango. The experiment was carried out in Completely Randomized Design wherein mango trees were sprayed with $CaCl_2$ in the following treatments: T_1: Control (no spray), T_2: 0.50% spray of calcium chloride at 30 days before harvest, T_3: 1.00% spray of calcium chloride at 30 days before harvest, T_4: 1.50% spray of calcium chloride at 30 days before harvest, T_5: 0.50% spray of calcium chloride at 15 days before harvest, T_6: 1.00% spray of calcium chloride at 15 days before harvest, T_7: 1.50% spray of calcium chloride at 15 days before harvest. They found that 1.50% $CaCl_2$ significantly increased the number of days taken for ripening of fruits, the shelf-life of fruits, physico-chemical parameters and organoleptic evaluation of mango fruits compared to control.

CHAPTER III
MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2013 to January 2014. The location of the site is in 23º 74 N latitude and 90º 35 E longitude with an elevation of 8.2 meter from sea level (Anon, 1989).

3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). The total rainfall of the experimental site was 83.6 mm during the study period. The average monthly maximum and minimum temperature were 27.17 ºC and 15.6 ºC respectively during the experimental period. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) and have been presented (Appendix I).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resource Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and presented in appendix II. The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below– AEZ No. 28 Soil series– Tejgaon General soil- Non-calcarious dark grey.

3.4 Plant Materials

Seed of lettuce cultivar, “Grand Rapid” collected from Kushtia seed store, Dhaka, was used in the experiment and sown on 8th November, 2013. It is leafy and spreading type as well as heat tolerant in nature.

3.5 Treatments of the experiment

The experiment was conducted to study the influence of plastic mulch and foliar application of calcium on growth and yield of lettuce. The experiment consisted of two factors as follows:

Factor A: Three types of mulching denoted as-

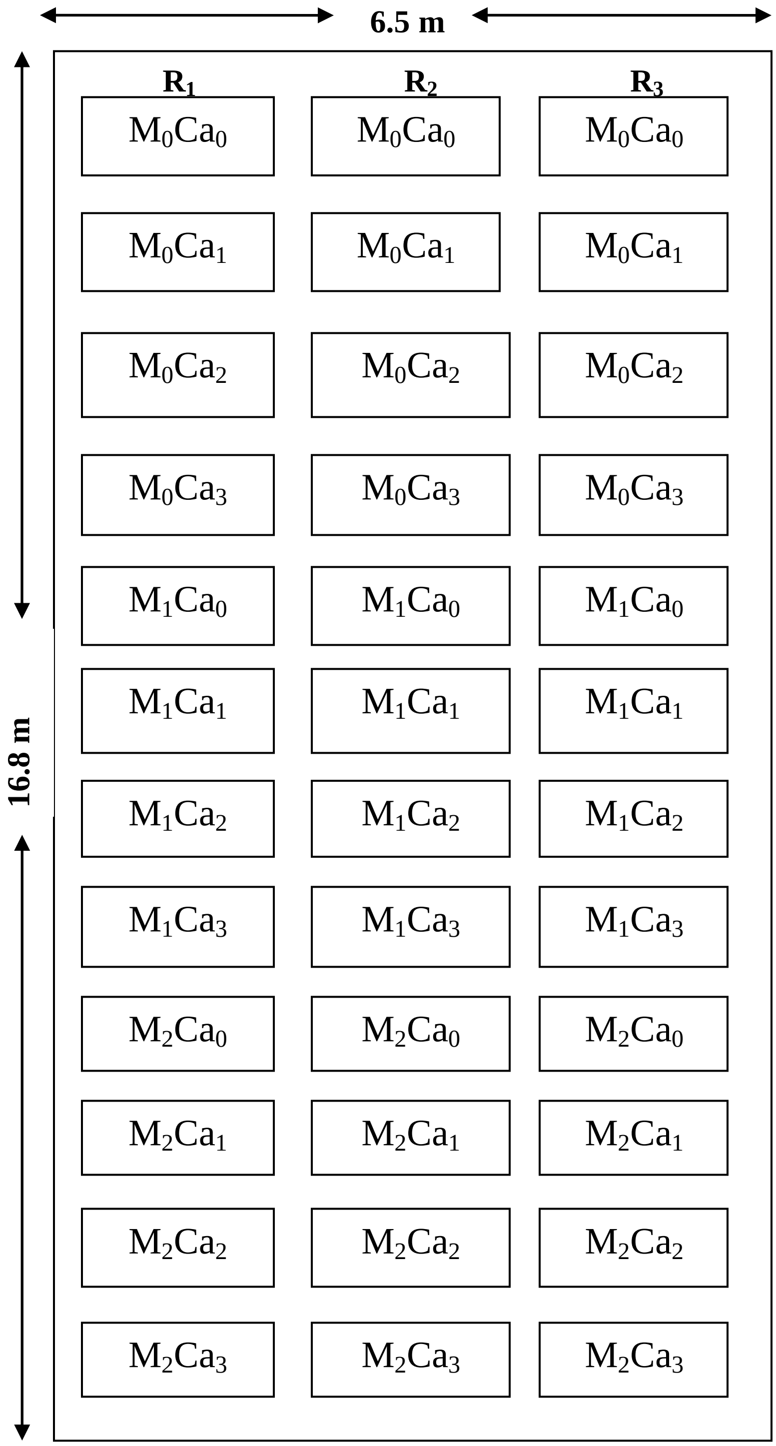
1. M_0: Control; No mulch
2. M_1: White plastic mulch
3. M_2: Black plastic mulch

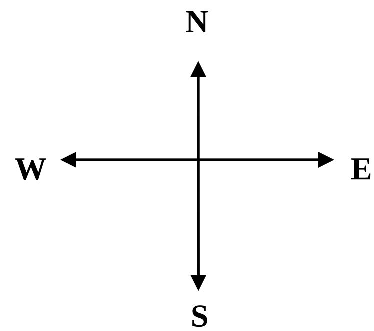
Factor B: Four concentrations of Ca denoted as-

1. Ca_0: Control; 0 ppm
2. Ca_1: 300 ppm
3. Ca_2: 450 ppm
4. Ca_3: 600 ppm

3.6 Experimental design and layout

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 16.8 x 6.5 m^2 was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments were allotted at random. Thus there were 36 unit plots altogether in the experimental field. The size of each plot was 1.5 m × 1 m. The distance between two blocks and two plots were kept 0.5 m and 0.4 cm, respectively. A layout of the experiment has been shown in Fig. 1.





Plot Size: 1.5 m x 1 m

Plot to plot: 40 cm

Block to block: 50 cm

Factor A: Mulch

M_0: Control (no mulching)

M_1: White polythene

M_2: Black polythene

Factor B: Calcium

Ca_0: Control (0 ppm)

Ca_1: 300 ppm

Ca_2: 450 ppm

Ca_3: 600 ppm

Fig 1: Layout of the Experiment

3.7 Land preparation

The land which was selected to conduct the experiment opened 15th October, 2013 with the help of a power tiller prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have good tilth which was necessary for getting better yield of the crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth**.**

3.8 Covering of land with polythene

The land was covered with black and white polythene paper with a number of small holes providing the space for seed sowing and let the land to conserve moisture for 7 days.

3.9 Application of Calcium

Calcium was applied on surface of leaf as in the solution form of calcium chloride. For the preparation of 300 ppm, 450 ppm and 600 ppm Ca solution, 13.65 mg, 15.35 mg and 17.43 mg $cacl_2$ was diluted respectively in 1000 ml of distilled water. Then the solution was applied to the plants at 25, 35 and 45 DAS.

3.10 Seed sowing

Lettuce seed was directly sown by providing line sowing method in the plot with additional light irrigation at 3rd week after land preparation.

3.11 Plant spacing

Seed were sown in the plot with maintaining distance between row to row was 25 cm and plant to plant was 30 cm.

3.12 Number of plants per plot

In each experimental plots were provided by 18 number of plants.

3.13 Intercultural operation

When the seeds were germinated in the plot, it was always kept under careful observation. Various intercultural operations like thinning, weeding were accomplished for better growth and development of lettuce seedlings.

3.13.1 Gap filing

Dead, injured and weak seedlings were replaced by new vigorous seedlings from the stock kept on the border line of the experiment field.

3.13.2 Weeding

Weeding was done three times in the experimental plots where it was necessary.

3.13.3 Irrigation

Light irrigation was given just after sowing of seed in the plot. A week after sowing the requirement of irrigation was envisaged through visual estimation. The plots were irrigated in every alternative day with a hosepipe until the entire plot was properly wet. Again, whenever the plants of a plot had shown the symptoms of wilting the plots were irrigated again.

3.13.4 Insects and Diseases

There was no incidence of insects and diseases.

3.14 Harvesting

Randomly selected four plants were harvested from each plot for data collection for 4 times. Harvesting was done at 30, 40, 50 and 60 days after sowing (DAS).

3.15 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Four (4) plants were sampled randomly from each unit plot for the collection of data.

3.15.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at 30, 40, 50 and 60 days after sowing (DAS) from the point of attachment of the leaves to the ground level up to the tip of the longest leaf.

3.15.2 Number of leaves per plant

Four numbers of leaves of randomly selected plants were counted at 30, 40, 50 and 60 DAS. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of four plants gave number of leaves per plant.

3.15.3 Length of leaf (cm)

The length of leaf was measured by using a meter scale. The measurement was taken from base to tip of the leaf. Average length of leaves which were matured and attained edibility was taken from four randomly selected plants. Data were recorded from 30, 40, 50 and 60 DAS. Average was expressed in centimeter (cm).

3.15.4 Breadth of leaf (cm)

The average breadths of leaves (which were matured and attain edibility) were taken from four randomly selected plants from each plot started at 30, 40, 50 and 60 DAS. Average was expressed in centimeter (cm).

3.15.5 Leaf area (cm^2)

Four plants were randomly selected from each plot and three fully mature leaves which attain edibility were collected at 60 DAS. Leaf areas of these leaves were measured with leaf area meter. Average was expressed in centimeter square (cm^2).

3.15.6 Chlorophyll contents (%)

Chlorophyll contents (%) was measured with four randomly selected leaf samples by SPAD and then average percentage was recorded.

3.15.7 Fresh weight per plant (gm)

Four randomly selected plants (which were matured and attained edibility) at 30, 40, 50 and 60 DAS were uprooted and average fresh weight of plants was recorded in gram (g).

3.15.8 Dry matter contents (%)

After harvesting, 100g of leaf sample previously sliced into very thin pieces were put into envelop and placed in oven and dried at 60°C for 72 hours. The sample was then transferred into desiccators and allowed to cool down to the room temperature and then final weight of the sample was taken to get dry weight.

3.15.9 Fresh yield per plot (kg)

Yield of lettuce per plot was recorded as the whole plant in every harvest within a plot (1.5m × 1m). Then fresh weight of head was taken by a triple beam balance at 30, 40, 50 and 60 DAS and the average weight was expressed in kilogram (kg).

3.15.10 Gross fresh yield (t/ha)

The yield of lettuce per hectare was calculated in ton by converting the total yield of leaves per plot.

3.15.11 Water loss with time (gm)

Water loss was measured by taking weight just after harvesting the crop and measured at every 2 hours interval for observing the fresh condition of the plant.

3.15.12 Organoleptic test

A panel of Judges consisting of 50 members were assigned to evaluate appearance crispiness, sweetness, bitterness, sourness, taste and flavor by organoleptic test on the basis of acceptability: Highly Acceptable (HA=7), Moderately Acceptable (MA=5) and Unacceptable (UA=2) for crispiness, taste and flavor (sweetness, bitterness and sourness) and appearance respectively (Villared *et al.*, 1979).

3.16 Statistical analysis

The recorded data on various parameters were statistically analyzed by using MSTAT C statistical package programme. The average for all the treatments was calculated and analysis of variance for all the characters was performed by F-test. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT) according to Gomez and Gomes, (1984).

3.17 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of Mulching and Calcium Chloride application. All input cost included the cost for lease of land and interests of running capital in computing the cost of production. The interests were calculated @ 15% in simple rate. Analysis was done according to the procedure of Alam *et al*. (1989).

The benefit cost ratio (BCR) was calculated as follows:

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

CHAPTER IV
RESULTS AND DISCUSSION

Data on different growth and yield of lettuce were recorded. The Analyses of Variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III-VIII. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height was measured at 30, 40, 50 and 60 days after sowing. The plant height varied significantly due to different polythene mulches at different growth stages and increased with plant age. At 30, 40, 50 and 60 DAS, the tallest plant (11.3, 14.9, 16.3 and 19.2 cm, respectively) was recorded from M_2. On the other hand, the shortest plant (8.2, 12.03, 14.4 and 16.9 cm, respectively) was recorded from M_0 for 30, 40, 50 and 60 DAS, respectively. Black polythene mulch showed superior performance in plant height than control, (Fig. 2). The increased plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. Changes in the plant height have been observed by using different mulches and plastic mulch increased the plant height than other mulches (Shinde *et al.*, 1999).

Calcium concentrations presented a strong positive correlation with the amount of calcium in nutrient solution. Different levels of Calcium showed significant variation for plant height of lettuce at 30, 40, 50 and 60 DAS (Fig. 3). At 30, 40, 50 and 60 DAS, the tallest plant (11.2, 14.8, 16.7 and 19.5 cm, respectively) was recorded from Ca_3 whereas the shortest plant (8.5, 12.2, 14.3 and 16.6 cm, respectively) was recorded from Ca_0. The result was attributed for calcium, which regulates some enzyme systems; and influences the growth and health of cells and conductive tissues. Kazemi (2014) also found that calcium chloride (10 and 15 mM) solutions as foliar sprays either alone or in combination helps to increase plant height of tomato.

Combined effect of different levels of Mulches and Calcium showed significant differences on plant height of lettuce at 30, 40, 50 and 60 DAS (Table 2). At 30, 40, 50 and 60 DAS, the tallest plant (12.6, 16.1, 17.7 and 20.8 cm, respectively) was recorded from M_2Ca_3, while the shortest plant (6.6, 10.9, 13.1 and 15.4 cm, respectively) was recorded from M_0Ca_0.

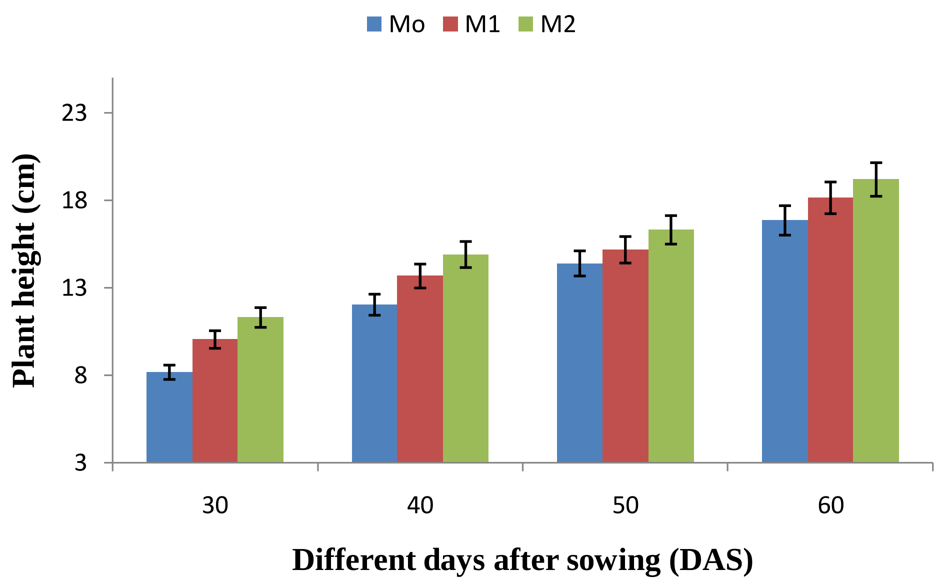


Figure 2. Effect of mulches on the plant height of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

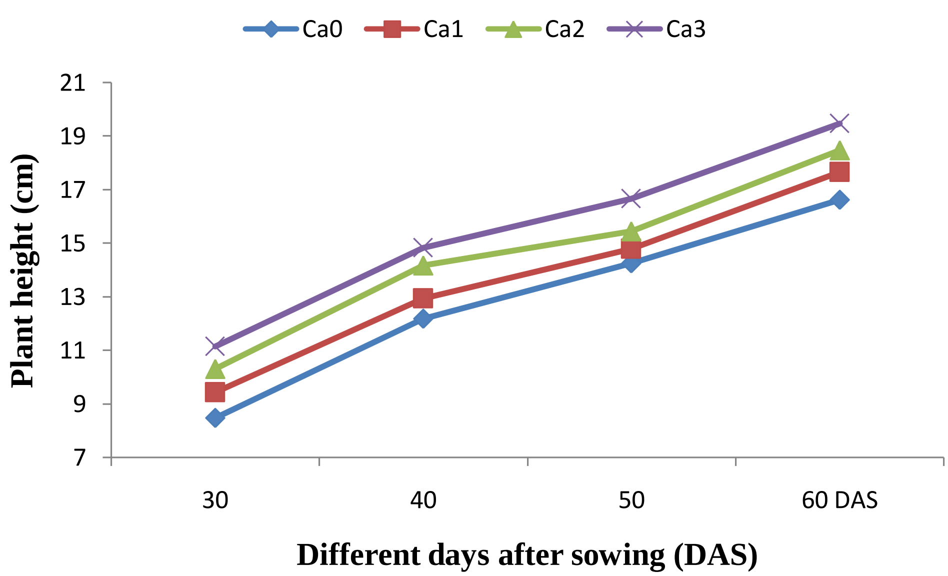


Figure 3. Effect of calcium levels on the plant height of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 2. Combined effect of mulches and different levels of Ca levels on plant height of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)			
	30	40	50	60
M_0Ca_0	6.55	10.89	13.11	15.41
M_0Ca_1	7.89	11.44	13.89	16.67
M_0Ca_2	8.89	12.72	14.67	17.44
M_0Ca_3	9.33	13.05	15.89	17.89
M_1Ca_0	8.89	12.11	14.33	16.78
M_1Ca_1	9.48	13.00	14.58	17.56
M_1Ca_2	10.24	14.22	15.33	18.45
M_1Ca_3	11.56	15.33	16.45	19.78
M_2Ca_0	9.96	13.53	15.33	17.67
M_2Ca_1	10.90	14.37	15.89	18.78
M_2Ca_2	11.80	15.58	16.33	19.55
M_2Ca_3	12.55	16.11	17.67	20.77
LSD	1.28	1.943	1.995	2.703
CV (%)	7.67	8.48	7.71	8.84

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.2 Number of leaves per plant

Mulches have significant effect on the number of leaves per plant. Mulches had the positive effect on generating and retaining higher number of leaves per plant. The highest number of leaves was counted in black polythene mulch and followed by white polythene mulch. Control always showed the least number of leaves (Fig 4). Due to different level of mulching at 30, 40, 50 and 60 DAS, the maximum number of leaves per plant (3.8, 5.9, 13.1 and 22.1, respectively) was found from M_3 whereas, the minimum number of loose leaves per plant (2.9, 4.7, 9.7 and 17.3 respectively) from M_0 for 30, 40, 50 and 60 DAS, respectively. The microclimatic condition improved by the mulches might have provided a suitable condition for producing higher number of leaves in the plants. Polythene mulches encouraged weed population which were suppressed under black polythene. Number of leaves was better for the chilli on plastic than control reported by. M. Ashrafuzzaman, *et al.* (2011)

Significant variation was recorded due to different levels of Calcium in terms of number of leaves per plant of lettuce at 20, 30, 40 and 50 DAS (Fig. 5). At 20, 30, 40 and 50 DAS, the maximum number of leaves per plant (3.9, 6.01, 12.8 and 22.2 respectively) was attained from Ca_3, while the minimum number of leaves per plant (2.4, 4.2, 7.8 and 15.8 respectively) was found from Ca_0, respectively. The result was attributed for calcium, which regulates some enzyme systems; and influences the growth and health of cells and conductive tissues including calcium contributes in the composition of the cell wall and the cell membrane. Calcium proved to be a good source which increased number of leaves (Abdul Ahad Qureshi, *et al.* 2012).

Different levels of Mulches and Calcium Chloride showed significant differences due to their combined effect on number of leaves per plant of lettuce at 30, 40, 50 and 60 DAS (Table 3). At 30, 40, 50 and 60 DAS, the maximum number of leaves per plant (4.3, 6.9, 14.7 and 24.8 respectively) was recorded from M_2Ca_0 and the minimum number of leaves per plant (2.4, 4.2, 7.8 and 15.8 respectively) was found from M_0Ca_0.

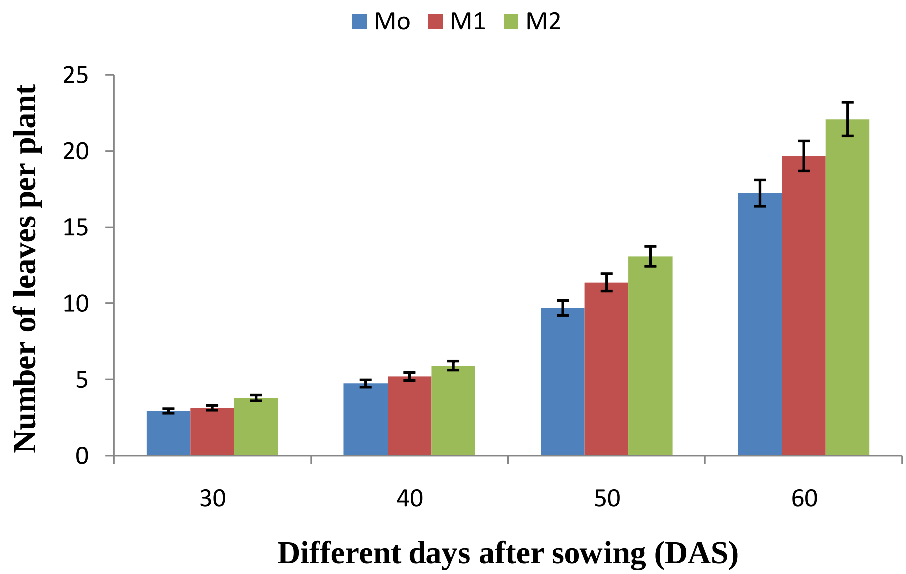


Figure 4. Effect of mulches on the number of leaves per plant of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

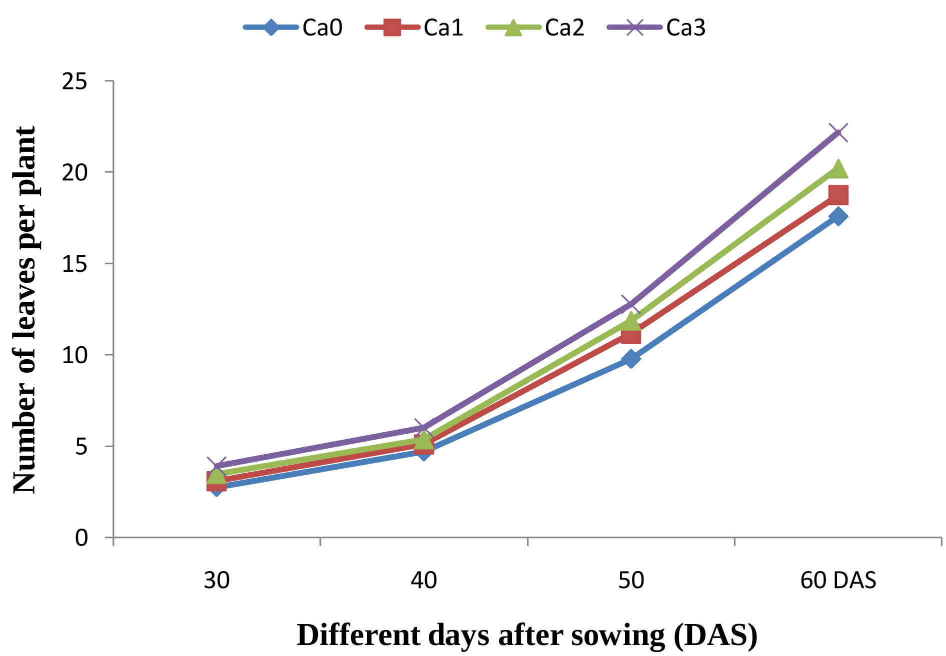


Figure 5. Effect of calcium levels on the number of leaves per plantof lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 3. Combined effect of mulches and different levels of Ca on number of leaves per plant of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)			
	30	40	50	60
M_0Ca_0	2.39	4.16	7.78	15.78
M_0Ca_1	2.68	4.56	9.95	16.33
M_0Ca_2	3.11	5.00	10.00	17.78
M_0Ca_3	3.60	5.27	11.11	19.11
M_1Ca_0	2.68	4.56	10.22	17.44
M_1Ca_1	2.89	4.94	11.00	18.33
M_1Ca_2	3.28	5.44	11.78	20.33
M_1Ca_3	3.78	5.89	12.56	22.66
M_2Ca_0	3.18	5.38	11.33	19.56
M_2Ca_1	3.67	5.78	12.56	21.56
M_2Ca_2	4.04	5.66	13.84	22.56
M_2Ca_3	4.33	6.89	14.67	24.78
LSD	0.48	0.84	1.47	2.63
CV (%)	8.52	9.35	7.64	7.88

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.3 Length of leaf

Length of leaf at all growth stages in lettuce plants was influenced by the mulching treatments. Statistically significant variation was found for leaf length of lettuce due to different levels of polythene mulch (Fig. 6). At 30, 40, 50 and 60 DAS, the highest leaf length (11.2, 14.8, 16.2 and 19.04 cm, respectively) was recorded from M_2. On the other hand, the lowest leaf length (7.9, 11.9, 14.3 and 16.8 cm, respectively) was recorded from M_0. Favorable weather condition and moisture of the soil are the important parameters affecting on leaf length of plant. Parmar *et al.* (2013) reported that all the plant growth, yield and quality characters were superior with black polyethylene mulch while, plants without mulch (control) resulted poor growth and yield.

Calcium concentrations presented a strong positive correlation with the amount of calcium in nutrient solution. Different levels of Calcium showed significant variation for leaf length of lettuce at 30, 40, 50 and 60 DAS (Fig. 7). At 30, 40, 50 and 60 DAS, the highest leaf length (10.9, 14.7, 16.5 and 19.4 cm, respectively) was recorded from Ca_3 whereas the lowest leaf length (8.4, 12.09, 14.1 and 16.5 cm, respectively) was recorded from Ca_0. The result was attributed for calcium, which regulates some enzyme systems; and influences the growth and health of cells and conductive tissues including calcium contributes in the composition of the cell wall and the cell membrane. Kazemi (2013) found calcium improved the yield contributing factors.

The results of indication in mulch or in calcium also show positive influence on growth by their combined form. Interaction effect of different levels of Mulch and Calcium showed significant differences on plant height of lettuce at 30, 40, 50 and 60 DAS (Table 4). At 30, 40, 50 and 60 DAS, the tallest plant (12.4, 16.01, 17.6 and 20.6 cm, respectively) was recorded from M_2Ca_3. While the shortest plant (6.4, 10.8, 13.0 and 15.3 cm, respectively) was recorded from M_0Ca_0.

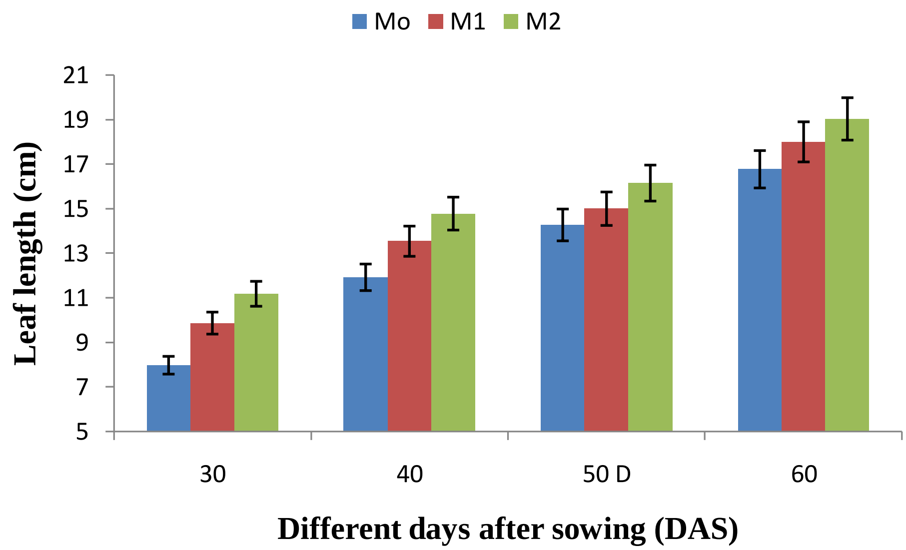


Figure 6. Effect of mulches on the leaf length of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

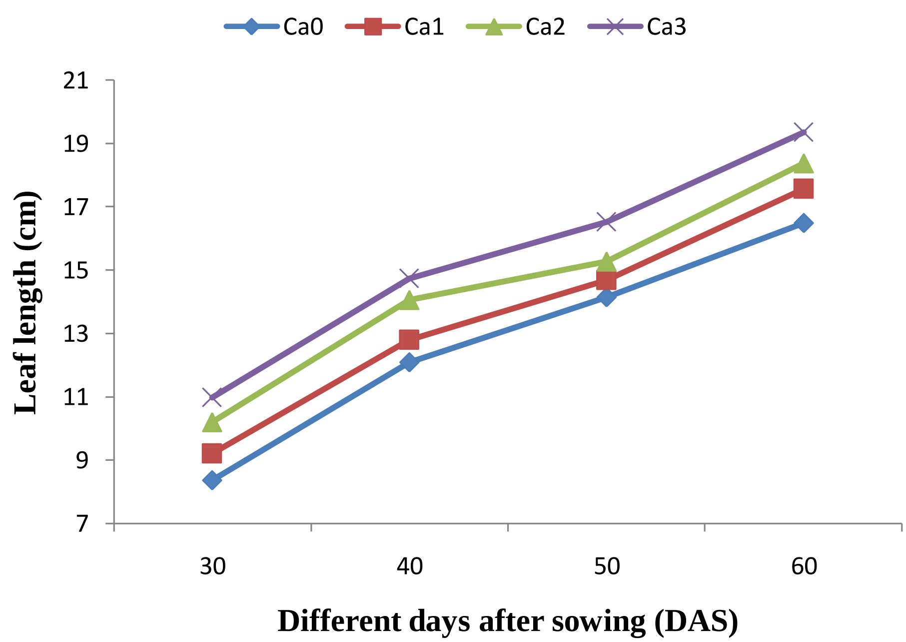


Figure 7. Effect of calcium levels on the leaf length of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 4. Combind effect of mulches and different levels of Ca on leaf length of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)			
	30	40	50	60
M_0Ca_0	6.44	10.80	13.00	15.31
M_0Ca_1	7.50	11.34	13.79	16.61
M_0Ca_2	8.82	12.62	14.57	17.38
M_0Ca_3	9.16	12.94	15.78	17.84
M_1Ca_0	8.82	12.04	14.25	16.60
M_1Ca_1	9.33	12.82	14.47	17.46
M_1Ca_2	10.01	14.09	15.11	18.32
M_1Ca_3	11.33	15.23	16.22	19.68
M_2Ca_0	9.810	13.43	15.17	17.57
M_2Ca_1	10.78	14.24	15.78	18.61
M_2Ca_2	11.73	15.47	16.15	19.44
M_2Ca_3	12.44	16.01	17.56	20.55
LSD	1.29	1.726	2.075	2.683
CV (%)	7.87	7.59	8.09	8.83

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.4 Breadth of leaf

Mulch color had significant effects on breadth of leaf. Black polythene mulch has positive influence on breadth of leaf compared to bare soil. The highest breadth of leaf was recorded for due to different level of mulches at 30, 40, 50 and 60 DAS under the present trial (Fig 8). At 30, 40, 50 and 60 DAS, the highest breadth of leaf (8.2, 11.1, 14.9 and 17.5 cm, respectively) was found from M_2 whereas, the lowest breadth of leaf (5.1, 8.01, 11.8 and 14.7 cm, respectively) from M_0 for 30, 40, 50 and 60 DAS, respectively. The surface color of polythene mulch can change the quantity of light and spectral balance reaching plants, with resulting effects on plant growth. Plant growth, yield and quality characters were superior with black polyethylene mulch while, plants without mulch (control) resulted poor growth and yield (Parmar *et al.* 2013)

Calcium concentrations presented a strong positive correlation with the amount of calcium in nutrient solution. Different levels of Calcium showed significant variation for leaf breadth of lettuce at 30, 40, 50 and 60 DAS (Fig. 9). At 30, 40, 50 and 60 DAS, the highest leaf breadth (7.5, 11.5, 16.1 and 16.5 cm, respectively) was recorded from Ca_3 whereas the lowest leaf breadth (5.8, 9.2, 13.9 and 14.7 cm, respectively) was recorded from Ca_0. The result was attributed for calcium, which regulates some enzyme systems; and influences the growth and health of cells and conductive tissues including calcium contributes in the composition of the cell wall and the cell membrane. Kazemi (2013) found calcium improved the yield contributing factors.

The results of indication mulch and calcium showed positive influence on growth by their combined form. Interaction of Mulch and Calcium Chloride showed significant differences due to their combined effect on number of leaves per plant of lettuce at 30, 40, 50 and 60 DAS (Table 5). At 30, 40, 50 and 60 DAS, the maximum leaf breadth (9.6, 13.5, 18.0 and 17.3 cm, respectively) was recorded from M_2Ca_3 and the minimum leaf breadth (4.7, 7.8, 12.9 and 13.6 cm, respectively) was found from M_0Ca_0.

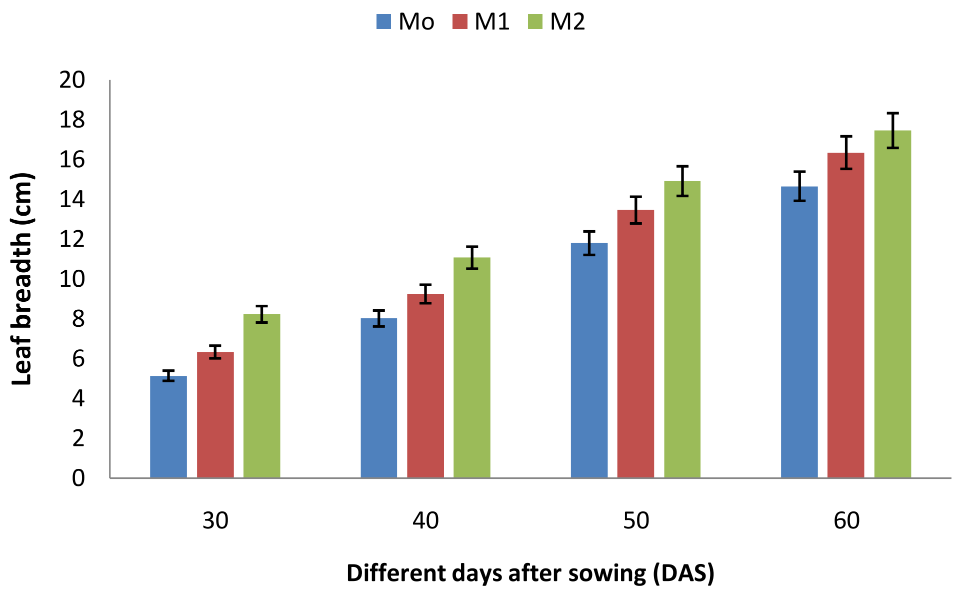


Figure 8. Effect of mulches on the leaf breath of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

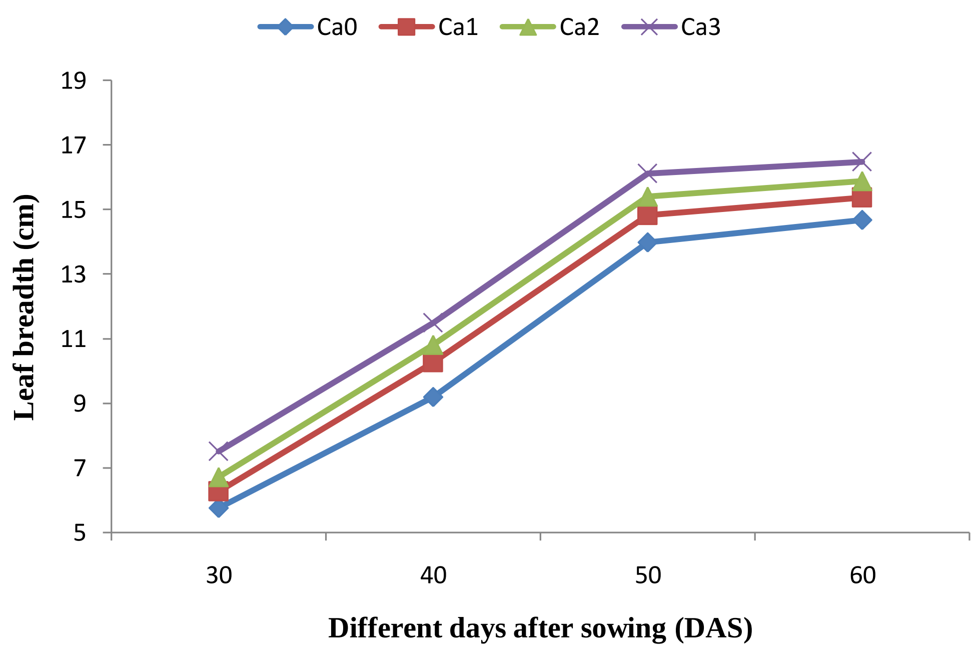


Figure 9. Effect of calcium levels on the leaf breath of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca0= 0 ppm (control) Ca1= 300 ppm Ca2= 450 ppm Ca3= 600 ppm

Table 5. Combined effect of mulches and different levels of Ca on leaf breadth of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)			
	30	40	50	60
M_0Ca_0	4.68	7.78	12.95	13.61
M_0Ca_1	5.00	8.83	13.67	14.10
M_0Ca_2	5.29	9.50	13.89	15.00
M_0Ca_3	5.56	9.94	14.67	15.89
M_1Ca_0	5.72	9.17	13.64	14.78
M_1Ca_1	5.83	10.11	13.99	15.78
M_1Ca_2	6.33	10.61	14.89	16.00
M_1Ca_3	7.41	11.06	15.67	16.22
M_2Ca_0	6.89	10.62	15.34	15.67
M_2Ca_1	7.95	11.83	16.84	16.22
M_2Ca_2	8.50	12.33	17.45	16.67
M_2Ca_3	9.56	13.45	18.00	17.34
LSD	0.9166	1.451	2.176	2.304
CV (%)	8.25	8.21	8.52	8.72

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4. 5 Fresh weight per plant (gm)

Mulching produced significantly higher fresh weights per plant than the controls. The highest fresh weight per plant of lettuce was measured from black polythene mulch and followed by white polythene mulch (Fig. 10). At 50 and 60 DAS, the highest fresh weight per plant (12.2, 20.9, 125.2 and 262.0 g, respectively) was recorded from M_2. On the other hand, the lowest dry yield per plot (6.5, 11.9, 59.2 and 154.9 g, respectively) was recorded from M_0. Apparently sufficient soil moisture was conserved under black polythene mulch that might have improved the plant growth as well as fresh weight. Plots covered with black polythene mulch were produced higher fresh and dry weights of both vegetable crops (Mahadeen 2014).

Different levels of Calcium Chloride showed significant variation for fresh weight per plant at 30, 40, 50 and 60 DAS (Fig. 11). At 30, 40, 50 and 60 DAS, the highest fresh weight per plant (10.6, 19.5, 101.7 and 241.0 g, respectively) was recorded from Ca_3, whereas the lowest fresh weight per plant (6.7, 11.9, 71.8 and 166.2 g, respectively) was recorded from Ca_0. Calcium holding the structure of cell walls and stabilizing cell membranes and activates potassium to regulate the opening and closing of stomata to allow water movement from the plant. By this mechanism the plant can absorb necessary water for their growth. Hutchinson, *et al.* (2006) found vegetative growth, leaf yield and quality are influenced by calcium.

Combined effect of different levels of Mulches and Ca showed significant differences on fresh weight per plant at 30, 40, 50 and 60 DAS (Table 6). At 30, 40, 50 and 60 DAS, the highest fresh weight per plant (15.01, 26.9, 137.3 and 288.7 g, respectively) was recorded from M_2Ca_3. While the lowest fresh weight per plant (9.1, 17.9, 90.2 and 157.6 g, respectively) was recorded from M_0Ca_0.

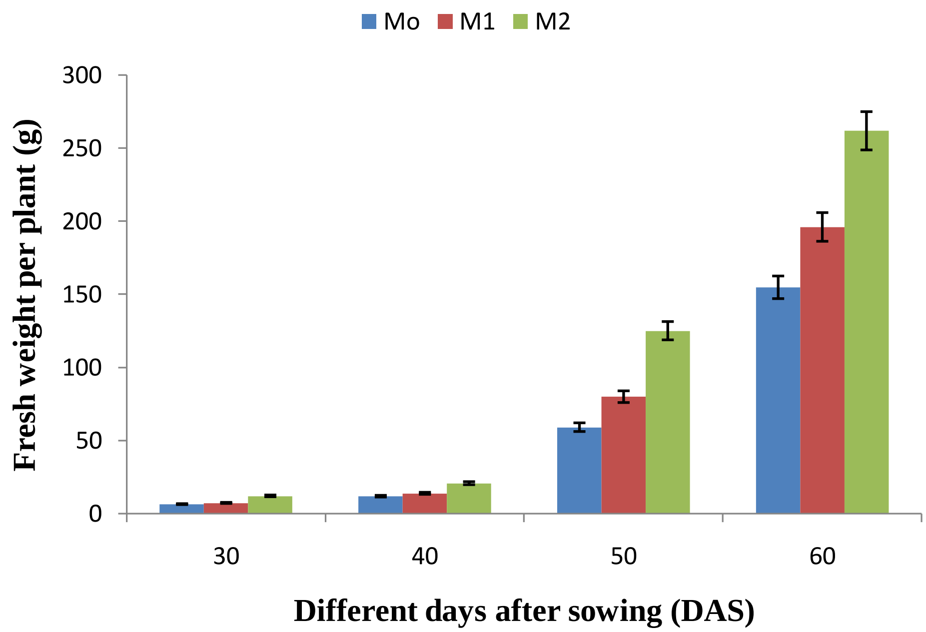


Figure 10. Effect of mulches on the fresh weight per plant of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

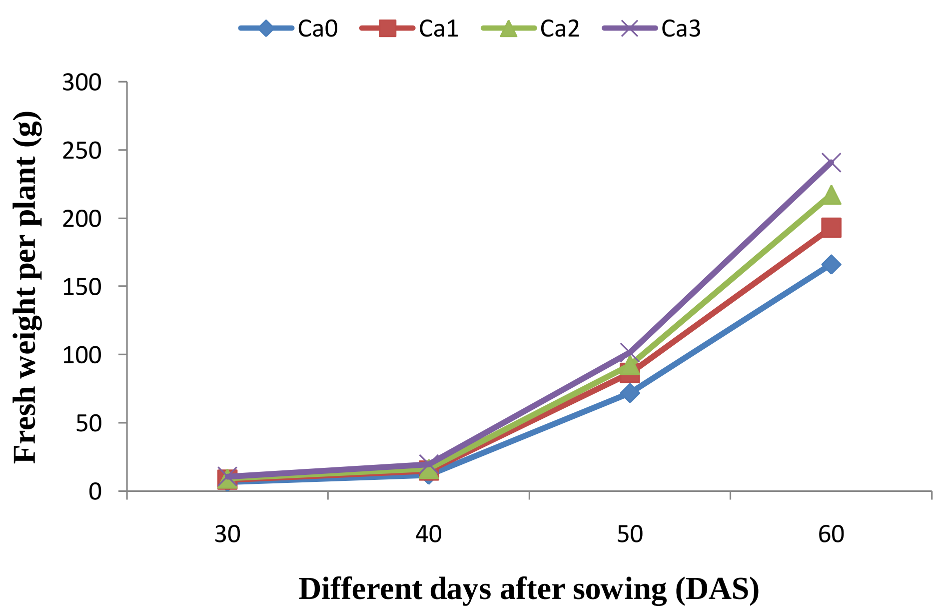


Figure 11. Effect of calcium levels on the fresh weight per plant of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca0= 0 ppm (control) Ca1= 300 ppm Ca2= 450 ppm Ca3= 600 ppm

Table 6. Combined effect of mulches and different levels of Ca on fresh weight per plant of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)			
	30	40	50	60
M_0Ca_0	5.120	8.950	52.22	116.4
M_0Ca_1	6.233	11.72	55.39	118.9
M_0Ca_2	6.890	12.91	62.26	180.8
M_0Ca_3	7.947	14.32	76.91	211.9
M_1Ca_0	5.743	11.01	64.26	173.6
M_1Ca_1	6.880	13.06	81.60	191.5
M_1Ca_2	7.960	14.48	83.65	197.4
M_1Ca_3	8.907	17.23	90.72	222.3
M_2Ca_0	9.337	15.76	109.0	217.0
M_2Ca_1	11.67	19.41	123.1	269.0
M_2Ca_2	12.75	21.44	131.4	273.4
M_2Ca_3	15.01	26.91	137.3	288.7
LSD	1.413	2.58	3.17	2.51
CV (%)	9.58	9.77	7.73	6.64

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4. 6 Dry matter contents (%)

Both mulches produced significantly dry matter contents of leaf compared to the control. The highest dry weight per plant was measured from black polythene mulch and followed by white one (Fig. 12). At 30, 40, 50 and 60 DAS, the highest dry matter contents (11.8%, 13.8%, 14.7% and 14.6%, respectively) was recorded from M_2. On the other hand, the lowest dry matter contents (7.5%, 9.4%, 9.6% and 10.6%, respectively) was recorded from M_0. Apparently sufficient soil moisture was conserved under black polythene mulch that might have improved the plant growth. Khazaei *et al.* (2013) also found mulching had significant effects on leaf dry weight and total dry yield.

Calcium has an advantage for foliar fertilizer use being a soluble form of calcium. Different levels of calcium showed significant variation for dry matter contents at 30, 40, 50 and 60 DAS (Fig. 13). At 30, 40, 50 and 60 DAS, the highest dry matter contents(11.7%, 13.3%, 13.9% and 14.3%, respectively) was recorded from Ca_3, whereas the lowest dry matter contents(7.9%, 10.3% 10.6% and 11.0%, respectively) was recorded from Ca_0. This result may be attained for calcium performed in cell wall and general structure development that has pronounced effect on cell growth. Calcium application in combined with phosphorus and boron increased dry matter contents in groundnut (Rezaul, *et al.* 2013)

The results of indication mulching and calcium showed positive influence on growth by their combined form. Combined effect of different levels of mulches and Ca showed significant differences on dry matter contents at 30, 40, 50 and 60 DAS (Table 7). At 30, 40, 50 and 60 DAS, the highest dry matter contents(14.7%, 15.1%, 16.4% and 16.4%, respectively) was recorded from M_2Ca_3, While the lowest dry matter contents (6.6%, 7.8%, 8.2% and 9.1%, respectively) was recorded from M_0Ca_0.

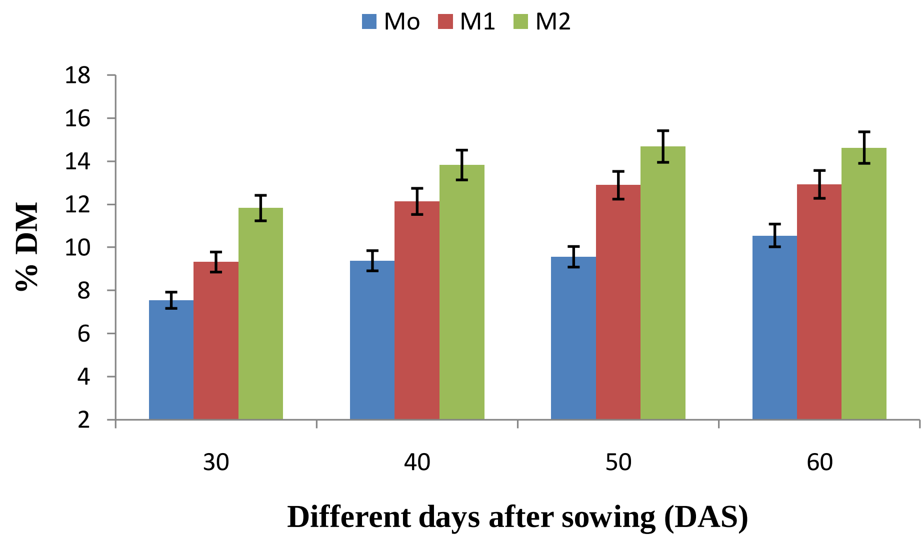


Figure 12. Effect of mulches on the dry matter contents of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

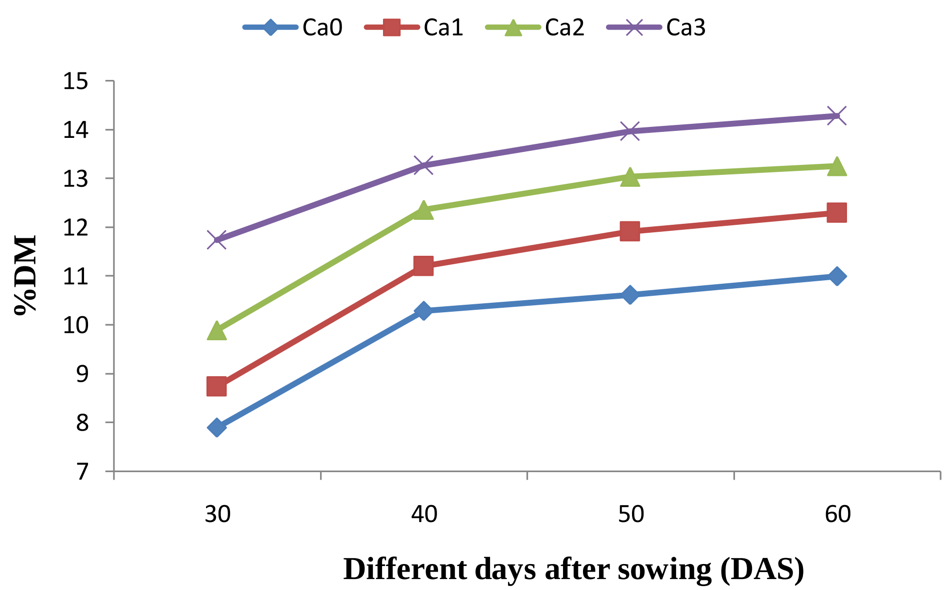


Figure 13. Effect of calcium levels on the dry matter contents of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 7. Combined effect of mulches and different levels of Ca on dry matter contents (%) of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)			
	30	40	50	60
M_0Ca_0	6.560	7.750	8.240	9.097
M_0Ca_1	7.280	8.760	8.827	10.07
M_0Ca_2	7.627	9.977	10.04	10.85
M_0Ca_3	8.727	11.05	11.16	12.20
M_1Ca_0	7.523	10.86	10.82	11.29
M_1Ca_1	8.370	11.61	12.57	12.52
M_1Ca_2	9.597	12.44	13.82	13.72
M_1Ca_3	11.80	13.63	14.34	14.20
M_2Ca_0	9.613	12.27	12.77	12.62
M_2Ca_1	10.56	13.27	14.32	14.30
M_2Ca_2	12.47	14.66	15.26	15.22
M_2Ca_3	14.68	15.13	16.40	16.43
LSD	1.461	1.346	1.614	1.678
CV (%)	9.01	6.74	7.7	7.8

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.7 Leaf Area $(cm)^2$

The results showed that mulch treatments significantly affected LA at growth stage. Statistically significant variation was recorded for leaf area of lettuce due to different levels of Mulching at 60 DAS (Fig. 14). At 60 DAS, the maximum leaf area (217 cm^2) was recorded from M_2. On the other hand, the minimum leaf area (186 cm^2) was recorded from M_0. This increase was attributed to the light absorbed into the plant leaf by the black polythene treatments. This has high correlation with the increase in lettuce leaf area. Kosterna (2015) found application of covers resulted in higher leaf area compared to cultivation without covers.

Different levels of Calcium showed statistically significant variation for leaf area of lettuce due to different levels of Mulching at 60 DAS (Fig. 15). At 60 DAS, the maximum leaf area (219 cm^2) was recorded from Ca_3. On the other hand, the minimum leaf area (189 cm^2) was recorded from Ca_0. These results attributed for calcium influence photosynthesis: elongation, water regulation and nutrient balance in plant tissue.

The results of indication mulching and calcium showed positive influence on growth by their combined form. Combined effect of different levels of mulches and calcium showed significant difference on leaf area of lettuce at 60 DAS (Table 8). At 60 DAS, the maximum leaf area (225 cm^2) was recorded from M_2Ca_3 which is statistically similar with M_0Ca_3 (218.6 cm^2) and closely followed by M_2Ca_2 (217.3 cm^2) while the minimum leaf area (180.9 cm^2) was recorded from M_1Ca_0.

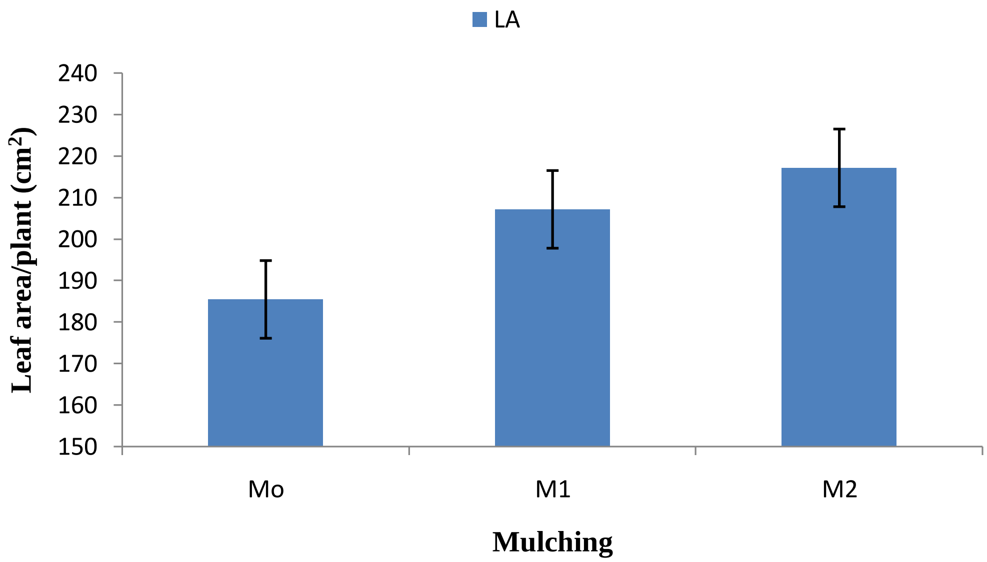


Figure 14. Effect of mulches on leaf area of lettuce at 60 days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

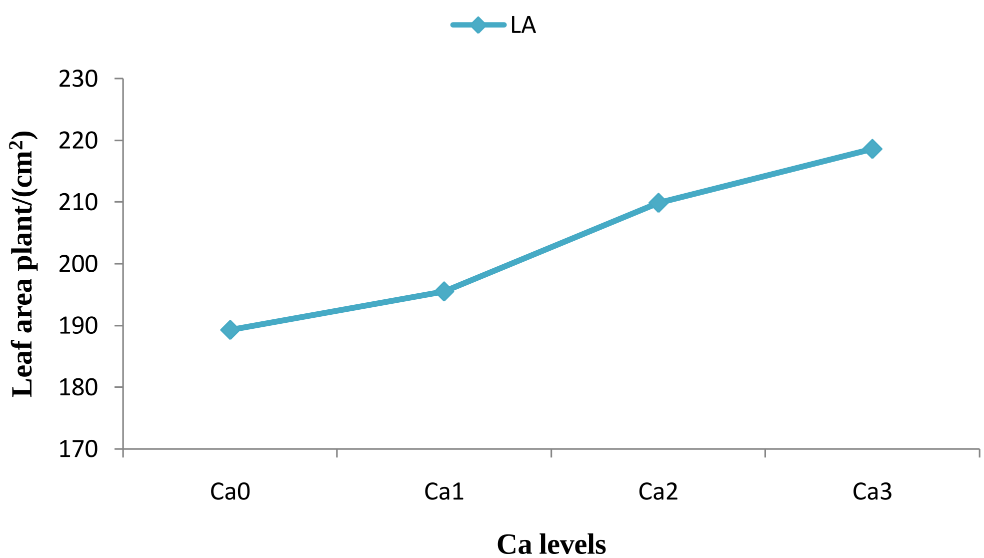


Figure 15. Effect of Ca level on Leaf area of lettuce at 60 days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 8. Combined effect of mulches and different levels of Ca on leaf area of lettuce at 60 days after sowing

Treatment combination	Days after sowing (DAS)
	60
M_0Ca_0	189.3
M_0Ca_1	195.5
M_0Ca_2	209.9
M_0Ca_3	218.6
M_1Ca_0	80.9
M_1Ca_1	172.7
M_1Ca_2	188.2
M_1Ca_3	201.4
M_2Ca_0	184.1
M_2Ca_1	202.5
M_2Ca_2	217.3
M_2Ca_3	225.0
LSD	41.08
CV (%)	11.93

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.8 Chlorophyll contents (%)

Results revealed that there were significant influenced on chlorophyll contents (%) by the polythene mulches. Statistically significant variation was recorded for chlorophyll contents of lettuce due to different levels of mulching at 60 DAS (Fig. 16). At 60 DAS, the maximum chlorophyll contents (17.6%) was recorded from M_2. On the other hand, the minimum chlorophyll contents (13.5%) was recorded from M_0. The increase in the chlorophyll contents of mulched plot was probably associated with the conservation of moisture and improved microclimate both beneath and above the soil surface. Panchal *et al.* (2001) who found that mulch had significant effect on total chlorophyll contents in chilli and black polythene mulch was the best for total chlorophyll contents among the mulches.

There was a significant relation with Ca on the chlorophyll contents (%) of leaf. Different levels of Calcium showed statistically significant variation for chlorophyll contents of lettuce due to different levels of mulching at 60 DAS (Fig. 17). At 60 DAS, the maximum chlorophyll contents (17.2%) was recorded from Ca_3. On the other hand, the minimum chlorophyll contents (14.4%) was recorded from Ca_0. Use of calcium chloride caused the leaf chlorophyll to be increased. This result indicates that the existence of calcium in the nutritional solution causes that the chlorophyll pigments of plant cells for better light absorption in the plant, to be formed. Calcium chloride (15 mM) spray either alone or in combination increased chlorophyll contents significantly (Mohsen 2014).

The single effect of mulching and calcium showed significant result in their combination. Interaction effect of different levels of mulching and calcium showed significant difference on chlorophyll contents (%) of lettuce at 60 DAS (Table 9). At 60 DAS, the maximum chlorophyll contents (18.5%) was recorded from M_2Ca_3. While the minimum chlorophyll contents (11.2%) was recorded from M_0Ca_0.

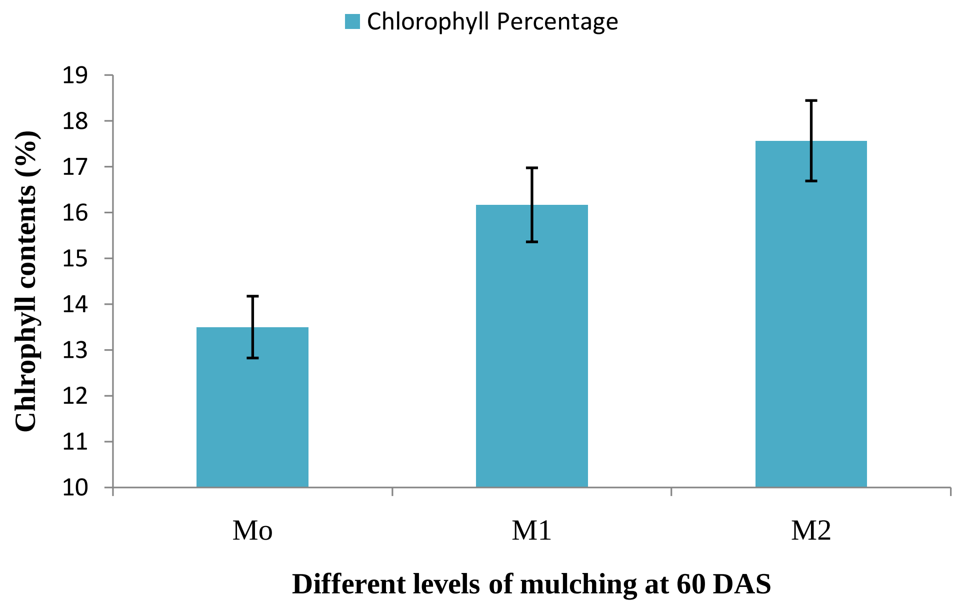


Figure 16. Effect of mulches on Chlorophyll percentage of lettuce at 60 days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

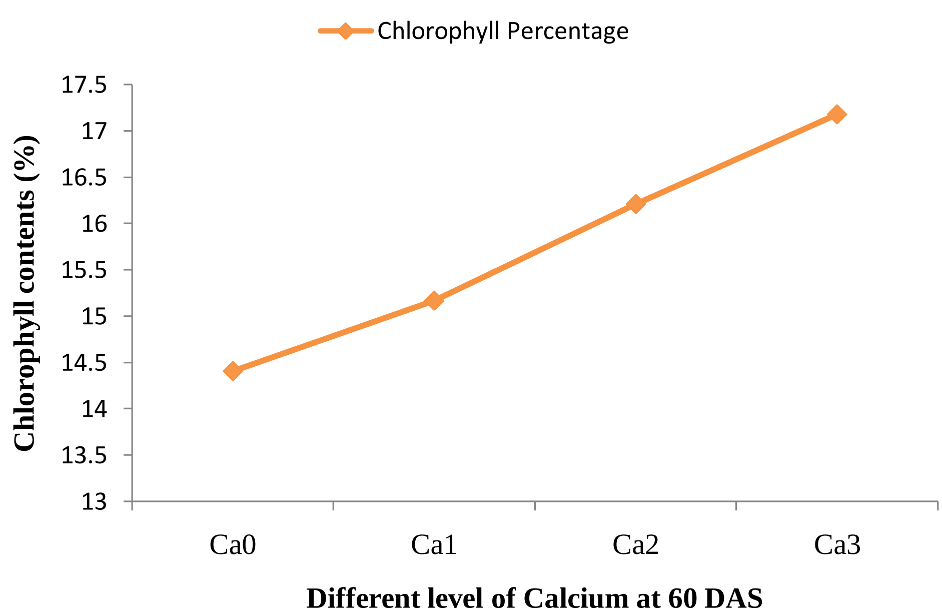


Figure 17. Effect of Calcium on Chlorophyll percentage of lettuce at 60 days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 9. Combined effect of mulches and different levels of Ca on chlorophyll percentage of lettuce at 60 days after sowing

Treatment combination	Days after sowing (DAS)
	60
M_0Ca_0	11.2
M_0Ca_1	12.4
M_0Ca_2	14.3
M_0Ca_3	16.1
M_1Ca_0	15.3
M_1Ca_1	15.8
M_1Ca_2	16.6
M_1Ca_3	16.9
M_2Ca_0	16.7
M_2Ca_1	17.3
M_2Ca_2	17.8
M_2Ca_3	18.5
LSD	2.63
CV (%)	9.85

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4. 9 Fresh yield (kg/Plot)

Mulches produced more fresh weight per plot compared to control. It meant that mulch had positive influence on fresh weight. The highest fresh weight per plot was measured in black polythene mulch, followed by white (Fig. 18). At 50 and 60 DAS, the highest fresh yield per plot (2 and 5 kg, respectively) was recorded from M_2. On the other hand, the lowest fresh yield per plot (1 and 3 kg, respectively) was recorded from M_0 for 50 and 60 DAS, respectively. The mulched plot was probably associated with the conservation of moisture and improved microclimate both beneath and above the soil surface. The suitable condition enhanced the plant growth and development and produced increased fresh weight compared to the control. Parmar *et al.* (2013) also found that all the plant growth, yield and quality characters were superior with black polyethylene mulch, while plants without mulch (control) resulted poor growth and yield.

Different levels of Calcium showed significant variation for fresh yield per plot at 50 and 60 DAS (Fig. 19). At 50 and 60 DAS, the highest fresh yield per plot (2 and 4 kg, respectively) was recorded from Ca_3 which was statistically similar with Ca_2, whereas the lowest fresh yield per plot (1 and 3 kg, respectively) was recorded from Ca_0 at 50 and 60 DAS. These results indicates that calcium performed in cell elongation, mycorrhizal fungal promotion, regulating enzyme systems, water regulation and nutrient balance in plant tissue. Calcium as foliar application improved the plant growth, yield and fruits quality of tomato (Abou El Hassan, *et al.*2015).

Interaction effect of different levels of mulches and $CaCl_2$ showed significant differences on fresh yield per plot of lettuce at 50 and 60 DAS (Table 10). At 50 and 60 DAS, the highest fresh yield per plot (2.5 and 5.2 kg, respectively) was recorded from M_2Ca_3, which was statistically similar (2.4 and 5.1 kg, respectively) with M_2Ca_2. While the lowest fresh yield per plot (1.3 and 2.2 kg, respectively) was recorded from M_0Ca_0.

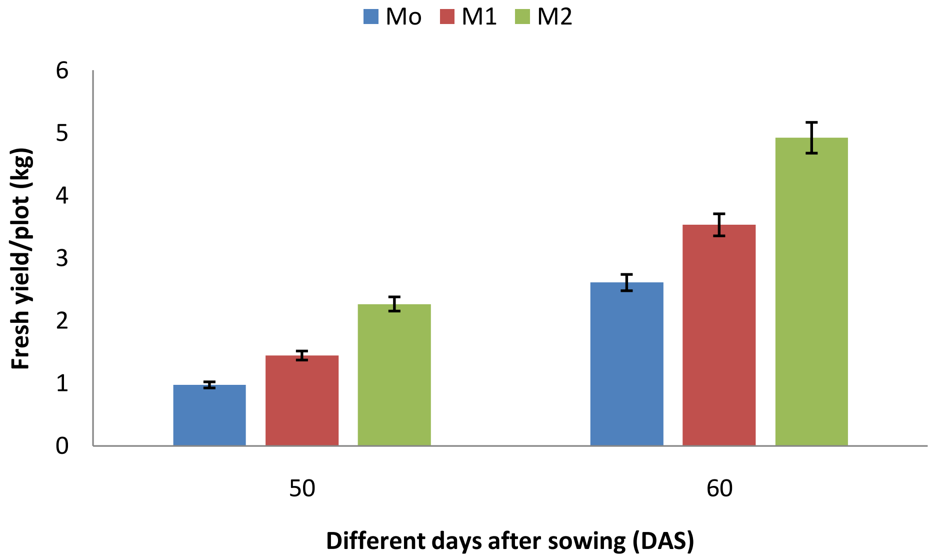


Figure 18. Effect of mulching on the fresh yield/plot of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

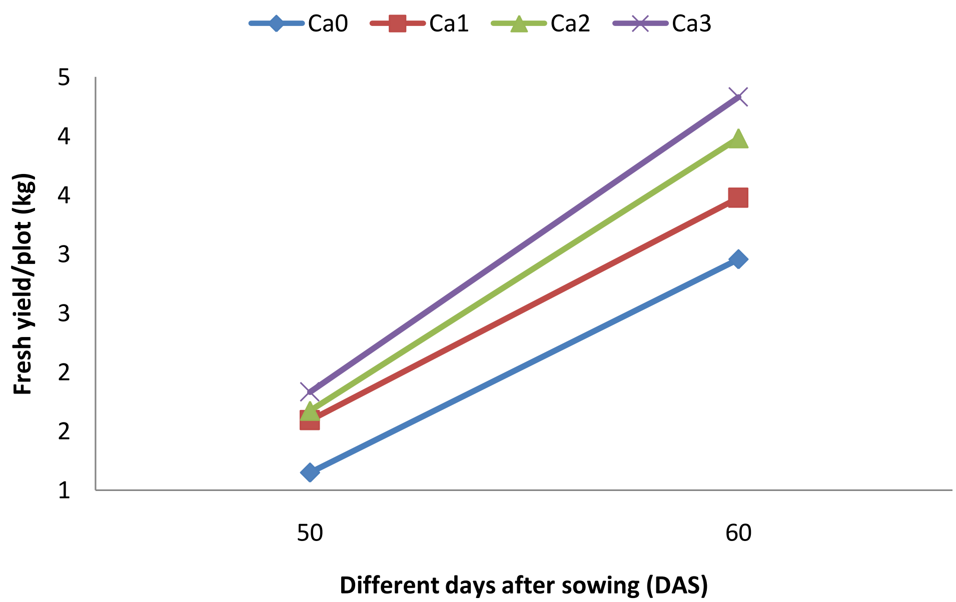


Figure 19. Effect of calcium levels on the fresh yield/plot of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 10. Combined effect of mulches and different levels of Ca on fresh yield/plot of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)	
	50	60
M_0Ca_0	1.29	2.23
M_0Ca_1	1.97	2.37
M_0Ca_2	1.48	3.25
M_0Ca_3	1.38	3.81
M_1Ca_0	1.36	3.12
M_1Ca_1	1.47	3.45
M_1Ca_2	1.51	3.55
M_1Ca_3	1.63	4.00
M_2Ca_0	1.99	4.51
M_2Ca_1	2.21	4.84
M_2Ca_2	2.39	5.14
M_2Ca_3	2.47	5.20
LSD	0.28	0.44
CV (%)	10.8	7.04

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.10. Water loss with time (g)

Different weights were recorded for finding the rate of water loss with time of lettuce at 6 and 24 hours interval from different treatment combination. The weights were recorded to determine the shelf life of lettuce. Maximum and Minimum water loss express the lowest and highest shelf life of lettuce respectively. The maximum and minimum water loss was measured from the difference between the initial weights and the weights after 6 and 24 hours (Table 11.).

Significant variation of weight loss (g) was found from different water loss (g) with time of lettuce at 60 DAS. At 6 hours interval, the minimum water loss (8.4 g) was recorded from M_2Ca_3. On the other hand the maximum water loss (18.8 g) was recorded from M_0Ca_0. At 24 hours interval the minimum water loss (34.1 g) was recorded from M_2Ca_3, whereas, the maximum weight loss (46.9 gm) was recorded from M_0Ca_0. The results indicate that Ca closing the stomata as less transpiration and increasing the water content in the plant and also improve water regulation system. This mechanism helps the plant to be fresh for long time. Habimana, *et al.*, (2014) found that 1.50% $CaCl_2$ significantly increased the shelf-life of fruits. Mtui, *et al.* (2014) also found that the use of mulch lead to fruits with consistently longer shelf life.

Table 11. Combined effect of polythene mulch and different levels of calcium on water loss with time (g) of lettuce

Treatment Combination	Water loss with time (g)			Water loss at 6 hours interval (g)	Water loss at 24 hours interval (g)
	Initial weight (g)	Weight after 6 hours (g)	Weight after 24 hours (g)		
M_0Ca_0	133.3	114.5	86.4	18.8	46.9
M_0Ca_1	158.7	144.3	113.6	14.4	45.1
M_0Ca_2	213.6	199.9	169.8	13.7	43.8
M_0Ca_3	281.4	265.6	238.7	15.8	42.7
M_1Ca_0	273.8	256.6	228.6	17.2	45.2
M_1Ca_1	233.3	222.9	191.8	10.4	41.5
M_1Ca_2	228.9	216.3	189.1	12.6	39.8
M_1Ca_3	266.8	256.6	228.7	10.2	38.1
M_2Ca_0	260.9	248.6	216.7	12.3	44.2
M_2Ca_1	276.5	265.4	238.8	11.1	37.7
M_2Ca_2	288.3	276.9	253.1	11.4	35.2
M_2Ca_3	243.7	235.3	209.6	8.4	34.1

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4.11 Organoleptic test on different treatments of lettuce

Organoleptic test are the aspects of food, water or other substances that an individual experiences via the senses—including taste, sight, smell and touch. Organoleptic tests were done to determine if lettuce can transfer tastes or odors to the materials and components. Different parameters were used for conducting organoleptic test. There was a group of 50 judges of 20-50 years age to evaluate taste of lettuce. All group members were the teachers, students and staff of Sher-e-Bangla Agricultural University (SAU), Dhaka. Consumer acceptability of lettuce depends on appearance viz. color, size and taste viz. crispiness, sweetness, sourness, and bitterness. Acceptability of lettuce was observed by a questionnaire and lettuce samples were served among the teachers, students and staff of the university.

The results of the preferential from the panelist have been summarized in table 12. When the preferential comments were converted into acceptability score lettuce grown with M_2Ca_3 treatment got the top score (1628) on the basis total acceptability ranking. While the lowest score (576) was recorded in the treatment combination of M_0Ca_0.

In case of crispiness, M_2Ca_3 scored top (341) among the treatments and the lowest score was 119 in M_0Ca_0. In case of sweetness, M_2Ca_2 scored highest (343) and the lowest (107) was in the M_1Ca_0 treatment. In respect of bitterness, highest score (325) was found in the treatment combination of treatment M_0Ca_0 and the lowest score (118) was recorded in treatment M_0Ca_0. In case of sourness, the highest score was (275) recorded in M_2Ca_3 treatment and the lowest (109) was from treatment M_0Ca_0. Considering appearance, the highest score was recorded (350) in M_2Ca_3 treatment and the lowest (103) was in M_0Ca_0 treatment combination.

The verification of taste and appearance in different combination was attributes for mulching and calcium application. It's got disappointment when lettuce doesn't get the optimum weather and soil nutrition which causes sourness and bitterness. Due to mulching and calcium the lettuce get proper water and cold which work miracles in restoring some of the sweetness to lettuce. Hossain (1996) conducted an experiment in amaranth by taking parameters of flavor taste, fiberness, and sweetness. Khan (1993) also conducted the same type of experiment on long yard bean by taking the parameter of skin color, shape and flavor taste, sweetness (after boiling). The present finding gives an indication of the consumers' likings the characteristic of the lettuce.

Table 12. Combined effect of Mulching and Calcium Chloride on organoleptic test of lettuce

Treatment Combination	Acceptability score					
	Crispiness	Sweetness	Bitterness	Sourness	Appearance	Total
M_0Ca_0	119	127	118	109	103	576
M_0Ca_1	150	115	130	120	216	731
M_0Ca_2	156	187	106	112	245	806
M_0Ca_3	145	179	155	140	265	884
M_1Ca_0	112	107	152	133	186	690
M_1Ca_1	192	228	176	189	210	995
M_1Ca_2	205	230	255	170	220	1080
M_1Ca_3	242	244	198	324	258	1266
M_2Ca_0	208	198	165	175	287	1033
M_2Ca_1	302	298	204	188	302	1294
M_2Ca_2	335	343	278	205	304	1465
M_2Ca_3	341	337	325	275	350	1628

Organoleptic test was done by following formula of Villared *et al.*, (1979).

Highly Acceptable (HA=7),

Moderately Acceptable (MA=5) and

Unacceptable (UA=2)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

4. 12 Gross fresh yield (ton/ha)

The use of polythene mulches significantly increased the gross fresh yield compared to non-mulched area. Statistically significant variation was recorded for gross yield per hectare of lettuce due to different levels of mulching at 50 and 60 DAS (Fig. 20). At 50 and 60 DAS, the highest gross yield per hectare (15 and 33 ton/ha, respectively) was recorded from M_2. On the other hand, the lowest gross yield per hectare (7 and 17 ton/ha, respectively) was recorded from M_0. Mulching causes better nutrition absorption, weed control and temperature adjacent in crown which improved growth and due to them total yield increased.

Different levels of Calcium Chloride showed significant variation for gross yield per hectare at 50 and 60 DAS (Fig. 21). At 50 and 60 DAS, the highest gross yield per hectare (12 and 28 ton/ha, respectively) was recorded from Ca_3, whereas the lowest gross yield per hectare (9 and 22 ton/ha, respectively) was recorded from Ca_0. These results indicates that calcium performed in cell elongation, mycorrhizal fungal promotion, regulating enzyme systems, water regulation and nutrient balance in plant tissue. Hassan, *et al.* (2015) found calcium, either individual or in combinations, increased vegetative growth and yield.

Interaction effect of different levels of Mulching and $CaCl_2$ showed significant differences on gross yield per hectare of lettuce at 50 and 60 DAS (Table 13). At 50 and 60 DAS, the highest gross yield per hectare (16.5 and 34.7 ton/ha, respectively) was recorded from M_2Ca_3, which was statistically similar (15.9 and 34.3 ton/ha, respectively) with M_2Ca_2. While the lowest gross yield per hectare (9.9 and 14.2 ton/ha, respectively) was recorded from M_0Ca_0.

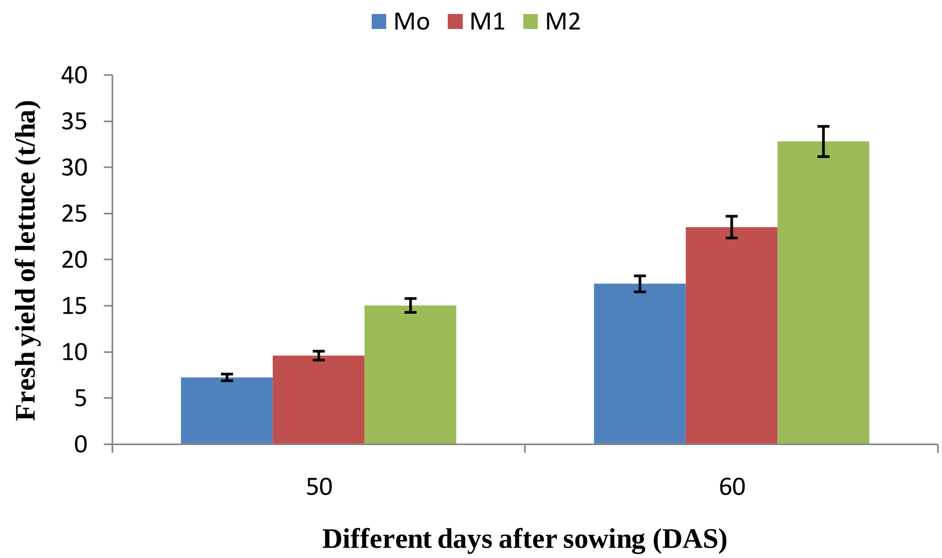


Figure 20. Effect of mulches on the fresh yield of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

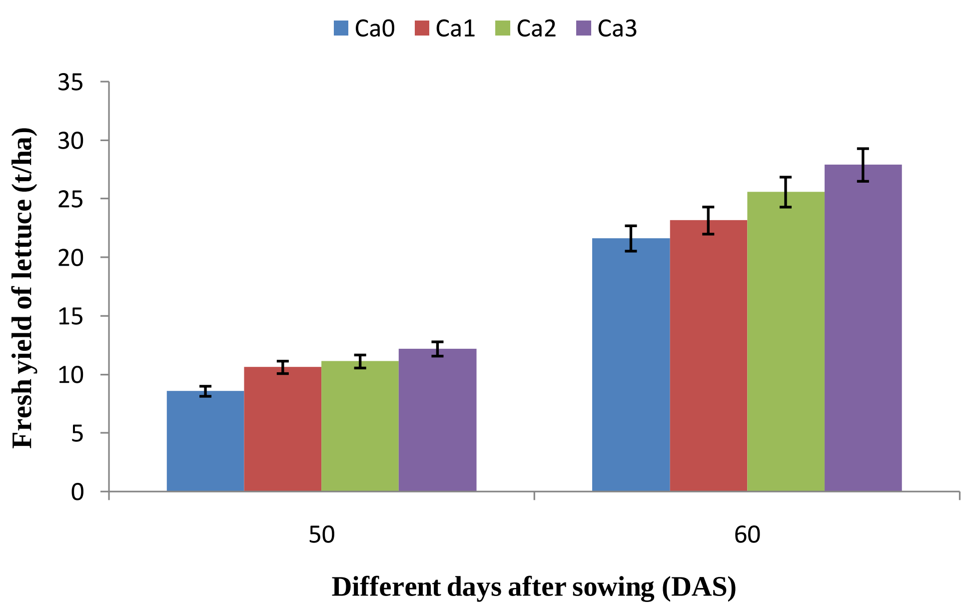


Figure 21. Effect of calcium levels on the fresh yield of lettuce at different days after sowing (Vertical bar indicates LSD at 0.5 level of significance)

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

Table 13. Combined effect of mulches and different levels of Ca on gross fresh yield (ton/ha) of lettuce at different days after sowing

Treatment combination	Different days after sowing (DAS)	
	50	60
M_0Ca_0	9.86	14.19
M_0Ca_1	10.34	18.26
M_0Ca_2	10.47	21.70
M_0Ca_3	11.23	25.43
M_1Ca_0	10.71	26.68
M_1Ca_1	11.79	22.98
M_1Ca_2	12.04	20.83
M_1Ca_3	12.89	23.68
M_2Ca_0	13.09	30.06
M_2Ca_1	14.75	32.28
M_2Ca_2	15.89	34.28
M_2Ca_3	16.48	34.65
LSD	1.46	3.44
CV (%)	8.11	8.26

LSD test at 5% level of significance.

M_0= No mulch M_1= White polythene mulch M_2= Black polythene mulch

Ca_0= 0 ppm (control) Ca_1= 300 ppm Ca_2= 450 ppm Ca_3= 600 ppm

CHAPTER V
SUMMARY AND CONCLUSION

The study was conducted at the Horticulture Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka to find out influence of polythene mulch and foliar application of calcium on growth and yield of lettuce. Data on different growth and yield of lettuce were recorded. The test crop used in the experiment was lettuce variety “Grand Rapid”. The experiment consisted of two factors: Factor A: Mulching (three levels) as- M_0- 0, M_1: White polythene, M_2: Black polythene. Factor B: Calcium Chloride (four levels) as- Ca_0: 0, Ca_1: 300 ppm, Ca_2: 450 ppm, Ca_3: 600 ppm. The two factors experiment was laid out in Randomized Complete Block Design with three replications.

In case of different levels of mulching, the tallest plant (11.3, 14.9, 16.3 and 19.2 cm, respectively), the maximum number of leaves per plant (3.8, 5.9, 13.1 and 22.1, respectively), the maximum leaf length (11.2, 14.8, 16.2 and 19.04 cm, respectively), the maximum leaf breadth (8.2, 11.1, 14.9 and 17.5 cm, respectively), the highest fresh weight per plant (12.2, 20.9, 125.2 and 262.0 g, respectively), the highest dry matter contents (11.8, 13.8, 14.7 and 14.6 %, respectively) at 30, 40, 50 and 60 DAS,. At 60 DAS, the highest leaf area (217 cm^2), the highest chlorophyll contents (17.6%). At 50 and 60 DAS, the highest fresh yield per plot (2 and 5 kg, respectively), the highest gross fresh yield per hectare (15 and 33 ton, respectively), were recorded from M_2, whereas the shortest plant (8.2, 12.03, 14.4 and 16.9 cm, respectively), the minimum number of leaves per plant (2.9, 4.7, 9.7 and 17.3, respectively), the minimum leaf length (7.9, 11.9, 14.3 and 16.8 cm, respectively), the minimum leaf breadth (5.1, 8.01, 11.8 and 14.7 cm, respectively), the lowest fresh weight per plant (6.5, 11.9, 59.2 and 154.9 g, respectively), the lowest dry matter contents (7.5, 9.4, 9.6 and 10.6 %, respectively), the lowest leaf area (186 cm^2), the lowest chlorophyll contents (13.5%), the lowest fresh yield per plot (1 and 3 kg, respectively), the lowest gross fresh yield per hectare (7 and 17 ton, respectively) were recorded from M_0.

For different levels of calcium, the tallest plant (11.2, 14.8, 16.7 and 19.5 cm, respectively), the maximum number of leaves per plant (3.9, 6.01, 12.8 and 22.2, respectively), the maximum leaf length (10.9, 14.7, 16.5 and 19.4 cm, respectively), the maximum leaf breadth

(7.5, 11.5, 16.1 and 16.5 cm, respectively), the highest fresh weight per plant (10.6, 19.5, 101.7 and 241.0 g, respectively), the highest dry matter contents (11.7, 13.3, 13.9 and 14.3 %) at 30, 40, 50 and 60 DAS. At 60 DAS, the highest leaf area (219 cm^2), the highest chlorophyll contents (17.2%). At 50 and 60 DAS, the highest fresh yield per plot (2 and 4 kg, respectively), the highest gross fresh yield per hectare (12 and 28 ton, respectively) were recorded from Ca_3, whereas the shortest plant (8.5, 12.2, 14.3 and 16.6 cm, respectively), the minimum number of leaves per plant (2.4, 4.2, 7.8 and 15.8, respectively), the minimum leaf length (8.4, 12.09, 14.1 and 16.5 cm, respectively), the minimum leaf breadth (5.8, 9.2, 13.9 and 14.7 cm, respectively), the lowest leaf area (189 cm^2), the lowest chlorophyll contents (14.4%), the lowest fresh weight per plant (6.7, 11.9, 71.8 and 166.2 g, respectively), the lowest dry matter contents (7.9, 10.3 10.6 and 11.0 %), the lowest fresh yield per plot (1 and 3 kg, respectively), the lowest gross fresh yield per hectare (9 and 22 ton, respectively) were recorded from Ca_0.

Due to combined effect of mulching and calcium, the tallest plant (12.6, 16.1, 17.7 and 20.8 cm, respectively), the maximum number of leaves per plant (4.3, 6.9, 14.7 and 24.8, respectively), the maximum leaf length (12.4, 16.01, 17.6 and 20.6 cm, respectively), the maximum leaf breadth (9.6, 13.5, 18.0 and 17.3 cm, respectively), the highest fresh weight per plant (15.01, 26.9, 137.3 and 288.7 g, respectively), the highest dry matter contents (14.7, 15.1, 16.4 and 16.4 g) at 30, 40, 50 and 60 DAS. At 60 DAS, the highest leaf area (225 cm^2), the highest chlorophyll contents (18.5%), the minimum water loss at 6 hours and 24 hours interval were (8.4 and 34.1 g, respectively), the most acceptability score (1628). At 50 and 60 DAS, the highest fresh yield per plot (2.5 and 5.2 kg, respectively), the highest gross fresh yield per hectare (16.5 and 34.7 ton/ha, respectively), were recorded from M_2Ca_3, whereas the shortest plant (6.6, 10.9, 13.1 and 15.4 cm, respectively), the minimum number of leaves per plant (2.4, 4.2, 7.8 and 15.8, respectively), the minimum leaf length (6.4, 10.8, 13.0 and 15.3 cm, respectively), the minimum leaf breadth (4.7, 7.8, 12.9 and 13.6 cm, respectively), the lowest leaf area (80.9 cm^2), the lowest chlorophyll contents (11.2%), the lowest fresh weight per plant (5.1, 8.9, 42.2 and 107.9 g, respectively), the lowest dry matter contents (6.6, 7.8, 8.2 and 9.1 %), the maximum water loss at 6 hours and 24 hours interval were (18.8 and 46.9 g, respectively), the lowest acceptability score (576), the lowest fresh yield per plot (1.3 and

2.23 kg, respectively), the lowest gross fresh yield (9.9 and 14.2 ton/ha, respectively) were recorded from M_0Ca_0.

Conclusion

Based on the experimental results, it could be concluded that polythene mulches and foliar calcium application had tremendous effects on the growth, and yield of lettuce. Black polythene mulch and 600 ppm $CaCl_2$ showed superior performance among the all combination. Therefore, the cultivation of lettuce using black polythene mulch and 600 ppm $CaCl_2$ could bring an ample scope for producing more species of lettuce as well as highest economic return.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November 2013 to January 2014

Month	*Air temperature (^0C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
November, 2013	25.82	16.04	78	00
December, 2013	22.4	13.5	74	00
January, 2014	24.5	12.4	68	00

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix II. Soil characteristics of experimental field as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
% Sand	27
% Silt	43
% clay	30
Textural class	silty-clay
p^H	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix III. Analysis of variance of the data on plant height and number of leaves of lettuce as influenced by different levels of mulching and calcium

Source of variation	Degrees of freedom	Mean square							
		Plant height (cm) at				Number of leaves per plant at			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	1.57	2.37	2.67	1.59	0.03	0.31	0.39	2.71
Level of Mulching (A)	2	29.91*	24.91*	11.14*	16.42*	2.40*	4.25*	34.49*	70.91*
Level of $CaCl_2$ (B)	3	11.95*	12.89*	9.71*	13.27*	2.25*	2.76*	14.43*	35.39*
Interaction (A×B)	6	0.18*	0.17*	0.09*	0.18*	0.02*	0.14*	0.43*	0.81*
Error	22	0.57	1.32	1.39	2.55	0.08	0.24	0.76	2.41

* Significant at 0.05 level of probability

* NS= Non Significant

Appendix IV. Analysis of variance of the data on leaf length and leaf breadth of lettuce influenced by different levels of mulching and calcium

Source of variation	Degrees of freedom	Mean square							
		Leaf length (cm) at				Leaf breadth (cm) at			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	1.08	1.94	2.04	2.26	1.22	0.09	1.44	0.47
Level of Mulching (A)	2	31.21*	24.70*	10.79*	15.33*	29.18*	28.19*	31.68*	10.04*
Level of $CaCl_2$ (B)	3	11.77*	12.82*	9.40*	13.31*	4.94*	8.47*	7.35*	5.27*
Interaction (A×B)	6	0.21*	0.17*	0.12*	0.16*	0.49*	0.14*	0.30*	0.25*
Error	22	0.58	1.04	1.50	2.51	0.29	0.73	1.65	1.85

* Significant at 0.05 level of probability

* NS= Non Significant

Appendix V. Analysis of variance of the data on fresh weight and dry matter contents (%) of lettuce influenced by different levels of mulching and calcium

Source of variation	Degrees of freedom	Mean square							
		Fresh weight (gm) at				Dry matter contents (%) at			
		30 DAS	40 DAS	50 DAS	60 DAS	30 DAS	40 DAS	50 DAS	60 DAS
Replication	2	0.44	1.23	306.31	122.98	0.19	0.11	0.25	0.48
Level of Mulching (A)	2	111.52*	262.44*	13660.61*	35058.21*	55.56*	60.52*	80.91*	50.57*
Level of $CaCl_2$ (B)	3	24.00*	89.92*	1409.65*	9271.78*	24.85*	15.25*	18.95*	17.53*
Interaction (A×B)	6	1.24*	5.62*	24.48*	1145.98*	1.50*	0.14*	0.28*	0.22*
Error	22	0.70	2.32	46.42	184.04	0.74	0.63	0.91	0.98

* Significant at 0.05 level of probability

* NS= Non Significant

Appendix VI. Analysis of variance of the data on chlorophyll percentage and leaf area (cm^2) of lettuce influenced by different levels of mulching and calcium

Source of variation	Degrees of freedom	Mean square	
		Chlorophyll Percentage (%) at 60 DAS	**Leaf Area (cm^2) at 60 DAS**
Replication	2	16.33	778.37
Level of Mulching (A)	2	51.32*	3161.56*
Level of $CaCl_2$(B)	3	13.20*	1600.88*
Interaction (A×B)	6	2.04*	115.60*
Error	22	2.41	588.42

* Significant at 0.05 level of probability

* NS= Non Significant

Appendix VII. Analysis of variance of the data on fresh yield per plot (g) and gross fresh yield/ha of lettuce influenced by different levels of mulching and calcium

Source of variation	Degrees of freedom	Mean square			
		Fresh yield per plot at		Gross fresh yield per hectare at	
		50 DAS	50 DAS	50 DAS	60 DAS
Replication	2	0.04	4.00	4.00	143.91
Level of Mulching (A)	2	5.14*	192.25*	192.25*	16785.79*
Level of $CaCl_2$ (B)	3	0.764*	20.68*	20.68*	2331.59*
Interaction (A×B)	6	0.080*	0.35*	0.35*	289.47*
Error	22	0.028	0.74	0.74	334.58

* Significant at 0.05 level of probability

* NS= Non Significant

Appendix VIII. Production cost of lettuce per hectare

(A) Material cost (Tk.)

Treatment Combination	Seed (Kg/ha)	Mulching and Calcium	Fertilizer				Sub total 1 (A)
			Cowdung	Urea	TSP	MP	
M_0Ca_0	10660	0	13200	6000	8600	9700	48160
M_0Ca_1	10660	1050	13200	6000	8600	9700	49210
M_0Ca_2	10660	1050	13200	6000	8600	9700	49210
M_0Ca_3	10660	1050	13200	6000	8600	9700	49210
M_1Ca_0	10660	14000	13200	6000	8600	9700	62160
M_1Ca_1	10660	15050	13200	6000	8600	9700	63210
M_1Ca_2	10660	15050	13200	6000	8600	9700	63210
M_1Ca_3	10660	15050	13200	6000	8600	9700	63210
M_2Ca_0	10660	18660	13200	6000	8600	9700	66820
M_2Ca_1	10660	19710	13200	6000	8600	9700	67870
M_2Ca_2	10660	19710	13200	6000	8600	9700	67870
M_2Ca_3	10660	19710	13200	6000	8600	9700	67870

Appendix VIII. Contd.

(B) Non-material cost (Tk./ha)

Treatment combination	Land preparation	Seed sowing	Intercultural operation	Harvesting	Sub total (B)	Total input cost 1 (A) + 1 (B)
M_0Ca_0	8000	6650	5250	6700	26600	68760
M_0Ca_1	13300	6650	8250	6700	34900	84110
M_0Ca_2	13300	6650	8250	6700	34900	84110
M_0Ca_3	13300	6650	8250	6700	34900	84110
M_1Ca_0	13300	6650	8250	6700	34900	97060
M_1Ca_1	13300	6650	8250	6700	34900	98110
M_1Ca_2	13300	6650	8250	6700	34900	98110
M_1Ca_3	13300	6650	8250	6700	34900	98110
M_2Ca_0	13300	6650	8250	6700	34900	101720
M_2Ca_1	13300	6650	8250	6700	34900	102770
M_2Ca_2	13300	6650	8250	6700	34900	102770
M_2Ca_3	13300	6650	8250	6700	34900	102770

Appendix VIII. Contd.

(C) Overhead cost and total cost of production (Tk.)

Treatment combinations	Cost of lease of land	Miscellaneous cost (5% of input cost)	Interest on running capital for 6 months (15% of the total input cost)	Total	Total cost of production (input cost + interest on running capital, Tk/ha)
M_0Ca_0	19500	3438	5157	28095	96855
M_0Ca_1	19500	4201	6308	30009	114119
M_0Ca_2	19500	4201	6308	30009	114119
M_0Ca_3	19500	4201	6308	30009	114119
M_1Ca_0	19500	4853	7280	31633	128693
M_1Ca_1	19500	4906	7358	31764	129874
M_1Ca_2	19500	4906	7358	31764	129874
M_1Ca_3	19500	4906	7358	31764	129874
M_2Ca_0	19500	5086	7629	32215	133935
M_2Ca_1	19500	5139	7708	32347	135117
M_2Ca_2	19500	5139	7708	32347	135117
M_2Ca_3	19500	5139	7708	32347	135117

Appendix IX. Questionnaire on taste and visual acceptability of lettuce.

Please give (√)against the desire treatment with the desire component.

Sample	Crispiness			Taste and Smell									Appearance		
	HA	MA	UA	Sweetness			Bitterness			Sourness			HA	MA	UA
M_0Ca_0															
M_0Ca_1															
M_0Ca_2															
M_0Ca_3															
M_1Ca_0															
M_1Ca_1															
M_1Ca_2															
M_1Ca_3															
M_2Ca_0															
M_2Ca_1															
M_2Ca_2															
M_2Ca_3															

Note:
HA= Highly Acceptable (7)
MA= Moderately Acceptable (5)
UA= Un-Acceptable (2)

Name and signature of judge**:** …….. ……………and…………………………….
Address**:** ………………………………………………………………………….
Age**:** ……………………Profession**:** ………………………………………………
Date**:** …………………………….