FOLIAR APPLICATION OF LIQUID FERTILIZERS ON FIVE LOCAL CHILLI (*Capsicum frutescens*) GERMPLASM

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CERTIFICATE

*This is to certify that the thesis entitled "**FOLIAR APPLICATION OF LIQUID FERTILIZERS ON FIVE LOCAL CHILLI (Capsicum frutescens) GERMPLASM**" submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in AGRICULTURAL BOTANY**, embodies the result of a piece of bona fide research work carried out by **MD. SHAH NEWAZ CHOWDHURY**, Registration No. **08-02900** 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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Alhamdulillah

All admiration to Almighty Allah

''Allah will raise those who have believed among you and those who were given knowledge, by degrees ''

DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

An experiment was conducted to study the morphphysiological characters, yield and quality of local chilli germplasms with different commercially available liquid fertilizers at Sher-e-Bangla Agricultural University, Dhaka, during the period from October 2013 to July 2014. The experiment consist of five local germplasm of chilli *viz.* 'Akashi', 'Kajoli', 'Deshi kacha Morich', 'Bogra Morich', 'Dongfou' and three level of commercially available common liquid fertilizers *viz.* 'Control', 'Calsol', 'Wuxal'. The experiment was laid out in Randomized Complete Block Design with four replications. Among germplasms, maximum number of fruits plant^{-1} (268.3) was found in 'Kajoli' whereas lowest from 'Dongfou'. Maximum vitamin-C was found in green and dry chilli fruits (76.44 mg/100g and 42.55 mg/100g), of the germplasm 'Akashi' whereas minimum vitamin-C was recorded in green and dry fruits from 'Deshi kacha morich'. The germplasm 'Akashi' gave the highest fresh fruits yield (18.1 t ha^{-1}), followed by Deshi kacha morich (16.9 t ha^{-1}) and Bogra morich produced the lowest fresh yield (13.3 t ha^{-1}). Among the liquid fertilizers, maximum number of fruits plant^{-1} (214.8), vitamin-C content in green and dry chilli fruits (75.3 mg/100g and 39.5 mg/100g) and fresh fruit yield (17.6 t ha^{-1}) were found from calsol whereas their minimum values were recorded in control. The germplasm 'Akashi' coupled with Calsol produced the maximum fresh fruit yield (19.6 t ha^{-1}) which was identical with Waxul with the same germplasm 'Akashi' (18.6 t ha^{-1}). In view of overall performances, this study suggests that calsol was a potential source of plant liquid fertilizer for suitable chilli production. So, Akashi with Calsol was best combination for higher fruit, yield and quality chilli production.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-ecological Zone
ANOVA	=	Analysis of Variance
Bot.	=	Botany
cm	=	Centimeter
RCBD	=	Randomized Completely Block Design
CV	=	Coefficient Variance
DAT	=	Days after Transplanting
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
Hort.	=	Horticulture
i.e.	=	That is
J.	=	Journal
K	=	Potassium
LSD	=	Least Significance Difference
mm	=	Millimeter
N	=	Nitrogen
P	=	Phosphorous
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
Viz.	=	Namely
%	=	Percentage
(^{0})	=	Degree

CHAPTER I

INTRODUCTION

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INTRODUCTION

Chilli (*Capsicum frutescens*) is an important spice crop grown all over Bangladesh. It belongs to the genus *Capsicum* and family Solanaceae. It is an unavoidable spice, which is liked for its pungency, spicy taste and its appealing color adds to the curry. There are many germplasm of pepper. Among these peepers *C. frutescens* are hot and *C. annum* are sweet. Hot peppers (chillies) pericarp have high content of crystalline colorless pungent substance known as alkaloid capsaicin ($C_{18}H_{27}NO_3$) (Udoh *et al.,* 2005). The heat sensation is produced by this substance. Which is used in the manufacture of sauces and curry powders and in preparation of pickles. It is quite rich in nutritive values and supposed to contain certain medicinal properties (Chowdhury, 1976). Green chillies are rich in vitamin A and C and the seed contain traces of starch (Saimbhi *et al.,* 1977; Sayed and Bagavandas, 1980). Particularly the red chilies contain higher amount of vitamin-C then yellow and especially green chilies (which are essentially unripe fruit). In addition, peppers are a good source of vitamin-B and vitamin B_6, carbohydrate, carotene, thiamine, riboflavin and niacin (Srivestav and Sanjeev, 1994). They are very high in potassium, magnesium, calcium and iron. *Capsicum frutescens* has economic importance in Bangladesh. In Bangladesh, chillies are grown in all the districts but plenty of chillies are produced in district of Bogra, Rangpur, Kurigram, Jamalpur, Natore and Jessore (BBS, 2014). 16141.73 hectares of land is under chilli cultivation in Bangladesh where 21,000 metric tons of chilli produced per annum in *kharif* season.105,000 tons of chilli was produced from 78346.45 hectares of land in *rabi* season (BBS, 2012). A numbers of cultivars are grown in Bangladesh differing in habit and yield but green chilli production was only 16.9 t ha^{-1} during 2010-2011 (BBS, 2011). This yield is very low compared to that of other chilli growing countries of the world. For the low yield of the crop, its annual production cannot meet up the total requirement and as such large quantity is to be imported every year. The low yield of chilli in

Bangladesh may be attributed to a number of reasons such as unavailability of quality seeds of high yielding germplasm, lack of screening of local germplasm and their improvement through fertilizer management and lack of disease and insect of the available cultivars. Low yield in Bangladesh could be attributed to lack of suitable cultivars (Uzo, 1990 and Dinakin *et al.,* 1990). In our country there are a few research works conducted for focusing on the germplasm screening of chilli and their growth, yield and quality improvement through foliar application of common liquid fertilizer. Foliar feeding means to apply liquid fertilizer directly to the leaves of the plant (Anonymous, 2004). Foliar fertilizers contain various macro and micro nutrients that are being used in vegetables. Which respond constructively to the application of small quantities of micro as well as macro-nutrients (Mallick and Mathukrishnan, 1980; Naz *et al.,* 2012). The key functions of micronutrients are to favor the photosynthesis and the synthesis of chlorophyll in green plants.

Foliar application of nutrients has become an important practice in the production of vegetables while application of fertilizer to the soil remains the basic method of feeding the majority of the vegetable and fruit plants. It has been found that a substantial percentage of the total requirements of certain plant nutrients can be fed by the foliar method. But very often it is found that a variety of unfavorable conditions in the soil make the nutrients unavailable to the plants. Sometimes these nutrients are lost from the soil through leaching and evaporation. Many studies have highlighted the advantages of foliar fertilization in improving plant growth, crop yield, nutrient uptake, product quality and environmentally safe. This technique can assure quick translocation of nutrients to various plant parts through leaf tissues under various nutrient deficiencies (Naruka *et al.,* 2000; Alkaff and Hassan, 2003; El-Aal *et al.,* 2010; Zodape *et al.,* 2011). It is well-established verity that macro or micro nutrients applied as foliar application become swiftly available to crop plants (Naz *et al.,* 2012).

At present there are many liquid fertilizers available in Bangladesh. To mitigate overall plant nutrition problem in which Calsol and Wuxal are two commercially available common liquid fertilizers those provide complimentary mingle of both macro and micronutrients. Application of these fertilizers may foster proper formation of vegetative and originative organs of plants, processes of formation and accumulation of assimilates in the plants, resulting in high and stable yields of good quality. Considering the above point in view the study was undertaken with following objectives.

Objectives:

- To evaluate morphphysiological characters, yield and quality of local chilli germplasm.

- To examine the influence of commercially available liquid fertilizers on local chilli germplasm.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

Chillies (*Capsicum frutescens* L.) are widely consumed throughout the world because of their pungency, flavor and color. It is a unique spice-cum-vegetable with a commercial value. With intense changing scenario of domestic spice market, wide variety of value added products based on spices and condiments have attained wide popularity. However, in Bangladesh little work has been performed on foliar application of nutrients on chilli germplasm. In this chapter a brief review of the related research done elsewhere in the world have been presented below under the following heads.

2.1 Chemical Composition of Chilli

Purseglove (1968) found that the pungent ingredient of chillies present in placenta is capsaicin ($C_{18}H_{27}NO_3$). A chilli contains about 0.1 percent of capsaicin contain chilli. Green chillies contain about 0.6 percent fat, moisture (83 percent), protein (3 percent), (7 percent) and fibre carbohydrate (6 percent). Chillies are a rich of vitamin C; *Capsicum annum* contains ascorbic acid (50-280 mg/ 100 g fruit) and *Capsicum frutescens* (2-50 mg / 100 g fruit).

Leung *et al.* (1972) observed that the composition of ripe chilli per 100 gm was protein contain 6.3%, fat 1.4%, mineral 2.1%, vitamin-C 96 mg % fiber, 15.0% and in dry chilli per 100 g contained protein 11.7%, fat 12.4%, fiber 13.4%, mineral 16.9% and vitamin-C 184 mg / 100 g fruit.

According to Bajaj *et al.* (1980), the chilli on an average contain ascorbic acid 131.06 mg %, oleoresin 68.53 ASTA units, coloring matter 67.38 ASTA units, capsaicin 0.34 %, crude fibre 26.75%, total ash 6.69% besides vitamin. Nutritional composition varies in chillies from germplasm to germplasm (Kaur *et al.* 1980)

Srivestava *et al.* (1994) reported that the proximate chemical composition of the green chilli per 100 g was protein (2.9%), mineral (1.0%), fat (0.6%), fiber (6.8 / 100 g fruit), carbohydrate (3.0), Ca (30 mg), P (80 mg), Fe (1.2 mg), carotene (175 μg), thiamine (0.19 μg), riboflavin (0.39 μg), niacin (0.9 μg) and vitamin-C (110 mg %) and in dry chilli per 100 g contained moisture (10.0%), protein (15.4%), fat (6.2%), mineral (6.1%), fiber (30.2%), carbohydrate (31.6%), Ca (160 mg), (P 370 mg), Fe (2.3 mg), carotene (345 μg), thiamine (0.93 μg), riboflavin (0.43 μg), niacin (9.5 μg) and vitamin-C (50 mg/ 100 g fruit).

2.2 Germplasms related information

Gogoi *et al*. (2002) found the highest plant height in Asamia Jalakia (71.21 cm). The number of primary branches was highest in Nadharia (7.83) and Kala J. Long (7.83). The number of days to first flowering was lowest in Soalkuchi (51.83). Khoti Jalakia had the highest number of flowers (662.67) and fruits (278.17) per plant, and fruiting percentage (42.00%). Fruit drop incidence was lowest in Singhasan (0.90%). Jayanti recorded the greatest fruit length (9.71 cm). Fruit diameter was greatest in Tupura Jalakia (1.83 cm), Thupuka Jalakia (1.81 cm) and Bogori Jalakia (1.64 cm). Balijuri had the highest fruit yield per plant (679.23 g), whereas Asamia Jalakia had the highest dry yield per plant (167.14 g). The weight of 1000 seeds was highest in LCA-206 (5.55 g) and lowest in Refugee (2.40 g).

Manju *et al.* (2002) observed high phenotypic and genotypic co-efficients of variation along with high heritability and genetic advance for all the characters. Correlation studies indicated a positive association of capsaicin with oleoresin, primary branches per plant and pollen viability and a negative association with pedicel length and fruit weight.

Sreelathakumary *et al.* (2004) observed higher phenotypic and genotypic co-efficients of variation for leaf area, fruits per plant, fruit weight, fruit length, fruit girth and yield per plant. High heritability coupled with high genetic advance observed for these characters imply the potential for crop improvement through selection.

Yamamoto *et al.* (2004) showed exactly the same qualitative characters and high similarity in quantitative characters in all 17 accessions from the Ryukyu Islands. These results agree with the results of biochemical analyses. Accessions from the Ryukyu Islands were both morphologically and biochemically very close to each other, indicating that the Ryukyu Islands is the end of the dispersal route of *C. frutescens* in Southeast and East Asia.

Smitha *et al.* (2006) observed significant differences among the genotypes with respect to both quantitative and qualitative characters. Correlation studies revealed that importance should be given to number of fruits per plant, fruit weight, number of primary branches, fruit length, fruit diameter and plant height during selection process, because these characters are going to contribute directly towards the yield.

Ukkund *et al.* (2007) observed high degree of variation for all characters. The difference between phenotypic co-efficient of variation and genotypic co-efficient of variation were found to be narrow for most of the traits except primary and secondary branches, tertiary branches, fifty per cent flowering, early and late fruit yield per plant. The high estimates of heritabilty was found for plant height (93.40%), days to first flowering (83.50%), percent fruit set (70.70%), number of fruits per plant (81.10%), fruit length (92.40%), ten fruit weight (92.40%) and total green fruits per plant (88.40%). Most of these characters also had moderate to high estimates of genetic advances as a percent over mean except days to first flowering.

Barche *et al.* (2014) found high significant difference due to genotypes for all the traits studied indicating sufficient genetic variability among the genotypes. Genotype 2011/CHIVAR-8 recorded the highest fruit weight (5.15 g) while fruit weight of genotype 2012/CHIVAR-2 was at par with 5.12 g green chilli. The genotype 2012/CHIVAR-2 recorded the highest fresh fruit yield (993.33 g) as well as dry fruit yield per plant (59.70g). Among the twenty two genotypes studied 2011/CHIVAR-8 was found to be superior followed by 2012/CHIVAR-2 and 2011/CHIVAR-6 for this region. They concluded that the genetic makeup, environmental factors and age of the plant affects the number of fruits and size of the fruits which in turn is responsible for overall yield efficiency.

Mehraj *et al.* (2014) found maximum number of flowers (49.8 plant^{-1}), number of fruits (33.0 plant^{-1}), length of individual fruit (7.5 cm) and number of seeds (69.0/fruit) was found from L_2, whereas maximum fresh weight of 50-fruits (65.4 g), dry weight of 50-fruits (17.7 g), fruit diameter (0.7 cm) and total yield (149.2 g plant^{-1} and 947.3 g plot^{-1}) was found from L_3. Maximum chlorophyll content (57.7%), CO_2 references (383.5 vpm), H_2O references as partial pressure (30.7 μmolm^{-2}s^{-1}) and Vitamin-C (80.5 mg/100 g fruit) was found from L_1, while maximum photosynthetic rate (5.3 μmolm^{-2}s^{-1}), and P.A.R incident on leaf surface (252.3 μmolm^{-2}s^{-1}) was recorded from L_3.

Chowdhury *et al.* (2015) showed wide differences in genotypic constituents reflected by morphological status in four varieties of Chilli V_1 (Magura), V_2 (Kajoli), V_3 (Vaduria) and V_4 (Bogra Morich). Major characters of growth and yield such as plant height, days to first flower bud initiation, number of flowers plant^{-1}, number of fruits plant^{-1}, number of fruits plot^{-1}, individual fruit weight, fruit length, fruit diameter, yield plant^{-1}, yield plot^{-1}, dry weight of fruit plant^{-1}, number of seed fruit^{-1} and Vitamin C content were influenced by cultivars. However, the maximum number of fruits (265.5 plant^{-1}and 2949.0 plot^{-1}), yield (291.3 g plant^{-1}and 4.6 kg plot^{-1}), dry weight of fruit (100.7 g plant^{-1}) and

Vitamin C (83.1 mg/100 g fruit) was found from V_2, while minimum from V_4.Chlorophyll content (SPAD) ranged from 60.9 to 52.8 among 4 chilli cultivars.

Zhani *et al.* (2015) found significant difference ($p<0.01$) in many characters of the pepper accessions. Souk Jedid accession produced plants with erect and short habit, small and lanceolate leaves and grouped flowers whereas the rest of accessions have dichotomous branching with bushy secondary stems, large and oval leaves and solitary flowers. The fruits had enrobing calyx, narrow triangular shape, dark red color at maturity and a smooth to slightly wrinkled surface in addition they are pungent but difference was observed in attitude, sinuation of pericarp at basal part, surface texture and glossiness.

2.3 Foliar fertilizers (macro and micro nutrient) application

Sindhu and Tiwari (1993) conducted a field trial on a sandy loam soil during the *rabi* winter season with onion cv. Pusa Red. Plants received foliar sprays of Cu (1or 3 ppm), Zn (3 or 5 ppm), B (0.5 or 1.0 ppm), Fe (100 ppm) and Mn (0.25 ppm), individually or combined. The micronutrients were applied once at 50 days after planting, or twice at 50 and 65 days after planting. Bulb yield was highest (275q ha^{-1}) when l ppm Cu + 3 ppm Zn + 0.5 ppm B + 100 ppm Fe was applied twice.

Pascua *et al.* (1996) applied Green Bee all purpose and growth booster foliar fertilizers to explore the possibility of substituting soil applied fertilizer with foliar fertilizer on garlic plants. They reported that the plants fertilized with ½ fertilizer recommendation and supplemented with Green Bee all purpose + growth booster were tallest, most vigorous, produced heaviest bulbs and gave the highest yield per hectare.

Banik *et al.* (1997) was carried out an experiment to study the effect of foliar application of Zn, Fe and B with urea to mango cultivar 'Fazli'. Combined applications of 0.4% Zn and 1% urea produced the highest fruit number (48) and yield (32.53 kg/plant) compared with 32 and 20.38 kg plant^{-1}, respectively, in control. Fruit quality in terms of TSS (20.400 Brix) was enhanced markedly by the application of B at (0.4% Zn, 1% urea) to young mango plants.

Bhonde *et al.* (1995) evaluated the effect of zinc, copper and boron on onion crop. Bulb size and yield as well as quality of bulb were enhanced when micronutrients were applied in combination instead of alone. The foliar application of zinc 3 ppm, copper 1 ppm and boron 0.5 ppm were found to give maximum net return to the growers. Foliar spray of most of micronutrient treatments significantly increased the uptake of N, P, K, S, Zn, Fe, Cu, Mn and B in fruits and shoots of tomato.

Palaniappan *et al.* (1999) applied N and K fertilizers (100 and 75% of recommended rate), Multi-K and Polyfeed (Both at 1%) foliar fertilizers and the combination of these two fertilizer sets on tomato. The application of 100 % NK + 2 sprays of Polyfeed (30 and 45 days after sowing, DAS) + 3 sprays of Multi-K (60, 75 and 90 DAS) gave the highest tomato fruit yield, marketable yield, net income and benefit cost ratio. Similarly for chili, the treatment of 100% NK +3 sprays of Polyfeed + 2 sprays of Multi-K produced the highest number of fruits per plant, dry fruit yield, net income and benefit cost ratio. Increasing the frequency of Polyfeed spraying from 3 to 4 times not increase the number of chili fruits per plant.

Tumbare *et al.* (1999) applied NPK at recommended rate as solid fertilizer and as liquid fertilizer; the yield and yield component values increased with increasing fertilizer rate by liquid as compared to conventional application. After 1980s, the application of foliar fertilizers is the quickest way to deliver nutrients to the tissues and organs of the crop, and is proved that application of these micronutrients is beneficial to correct certain nutrient deficiencies.

Naruka *et al.* (2000) studied the effect of foliar application of zinc and molybdenum through foliar spray at 0.2, 0.4 and 0.6% and 30, 60 and 90 ppm, respectively. Increasing zinc and molybdenum levels resulted in increasing plant height, number of fruits, fruit diameter and fruit yield. However, increasing levels resulted in increasing growth and height fruit yield.

Selvi and Rani (2000) reported that okra plants were treated with NPK (40: 50: 30 kg ha^{-1}) alone, NPK + micronutrients (MNS; soil application of $FeSO_4$ at 50 kg $ha^{-1}$and Zn SO_4 at 25 kg ha^{-1}, or foliar spraying of $FeSO_4$ at 1.0% and Zn SO_4 at 0.5%) or foliar and soil application of microfood (SMF, 750 and 25 kg ha^{-1}, respectively). The highest yield, income and benefit cost ratio were recorded from NPK+SMF and MNS foliar treatment; whereas, lowest yield among the treated plants was recorded from the single NPK treatment.

Barge (2001) used the foliar fertilizers, ElamMax (27% Mn) at 0.5 pints/acre, Folizyme (12% N, 3% K, 3% Ca and 3% Mn) at 2 q $acre^{-1}$, Keylate (5% Mn) at 2 pints/acre, White Label (6% Mn) at 2 pints $acre^{-1}$ and Harvest More Urea Mate (N, P, K, Ca, Mg, B, Co, Cu, Mn, Mo and Zn) at 5 pounds $acre^{-1}$. All treatments resulted in higher yields of soybean than the control.

Yadav *et al*. (2001) conducted a study with five levels of zinc (0, 2.5, 5.0, 7.5, and 10.0 ppm) and four levels of boron (0, 0.50, 0.75, and 1.0 ppm) as soil application, as well as 0.5% zinc and 0.3% boron as foliar application in tomato. The highest fruit length, fruit breadth and fruit number were obtained with the application of 7.5 ppm zinc and 1.0 ppm boron.

Katkar *et al.* (2002) conducted an experiment to study the effect of foliar sprays of nutrients and chemicals on yield and quality of cotton. Results indicated that the foliar application of different nutrients and chemicals significantly increased seed cotton yield by 38.7, 37.1, 31.3 and 21.2% over control.

Naresh and Singh (2002) conducted a study on the effect of zinc (0.2, 0.4 and 0.6 %), copper (0.1, 0.2 and 0.3%) and boron (0.1. 0.2 and 0.3%) on the yield components of litchi plants and observed significant improvement in fruit set, normal fruit, cracked fruits and fruit maturity in the treated plants over control.

Silberbush (2002) stated that foliar fertilization is widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots. Ca and B which are immobile in the plant should be applied in small amounts at high frequency rather than in one application for correcting temporary deficiencies in vegetables.

Alkaff and Hassan (2003) evaluated the effect of foliar application 0, 2, 4, 6 g of power on the growth and yield of okra plants. Foliar application of 4g of power 4 litre had the highest value for fresh and dry weight, number of pods per plant, average yield, average pod weight and early yield.

Chattopadhyay *et al.* (2003) applied B at 0.28, 0.56 and 1.12 kg $ha^{-1}$and Mo at 0.1, 0.2 and 0.4 kg/ha alone or in combination (as single or double) to okra *cv Pusa Sawani* in field experiment. Mo at 0.4 kg ha^{-1} resulted in the highest yield of 223.18 q ha^{-1}, while B at 0.56 kg ha^{-1} produced the highest yield of 222.71 q ha^{-1}. B at 1.12 kg ha^{-1} + Mo at 0.2 kg ha^{-1} produced the highest yield of 229.37 q ha^{-1}.

Hatwar *et al.* (2003) carried out an experiment to study the effect of foliar application of micronutrients along with the recommended dose of fertilizer. They reported that the combined spraying of Zinc, Boron and Iron each @ 0.1 per cent along with recommended dose of NPK @ 150:50:50 resulted maximum height of the plant (70.36 cm), maximum number of branches per plant (11.12) and maximum number of fruits per plant (184.12).

Mishra *et al.* (2003) also observed significant improvement in chlorophyll content and fresh weight of kinnow treated with zinc, iron and boron. The balanced nutrients have been paid little attention in agriculture areas of developing world. The deficiencies of micronutrients have emerged in the farmer's field and are recognized as symptoms on foliage and reduction in the quality and yield of the crop.

Sharaf and El-Naggar (2003) conducted field experiment to record the response of carnation plant to phosphorus and boron foliar fertilization. The results showed that foliar application of P_2O_5 alone or in combination with different levels of B stimulated the length, diameter and dry weight of stem, number and dry weight of leaves per branch as well as enhanced flowering time, number, size and dry weight of flower per plant. The best results of vegetative growth and flowering characteristics were obtained at 200 mg P_2O_5 per liter plus 50mg B per liter.

Nava-Sanchez *et al.* (2004) reported that foliar fertilizer application in onion had inconsistent results, which prevented adequate management nutrition for this crop. A field experiment was established in 2001 to determine the effect of foliar fertilizer application on bulb yield and quality of onion through the evaluation of the activity of physiological processes, fertilizer penetration routes and canopy nutrient concentration. There was no increase in bulb yield and quality. There were also no significant differences in the expression of physiological variables such as CO_2 diffusion, CO_2 assimilation, stomatal conductance, stomatal resistance, transpiration rate, as well as N, P, K, Ca, Mg, B, Cu, Fe, Mn and Zn foliar tissue concentrations. When studying the penetration of foliar urea plus calcoflour colorant, urea entered through the stomata and to a lower degree through the cuticle of plants at 75 and 113 days after transplanting.

The benefit of micronutrients is not limited solely to the replenishment of the micronutrient itself but in addition micronutrient acts as catalyst in the uptake and use of certain macronutrients (Phillips, 2004).

Tuncay *et al.* (2004) investigated the effects of Superalg, NZN, Croptec and Polyfeed foliar fertilizers on yield and quality related characters of sunflower.

They had significant effects on seed yield, seed height, seed/husk ratio, oil content, plant height, seed dry matter and stem yield ($P<0.01$). The best results were obtained from Croptec and Polyfeed fertilizers. However, according to economic analysis, NZN application had the highest gross margin per hectare.

Bhatt and Srivastava (2005) investigated the effects of the foliar application of B, Zn, Mo, Cu, Fe Mn, mixture of these nutrients, and Multiplex (a commercial micronutrient formulation) on the nutrient uptake and yield of tomato (Pusa hybrid-1). Zinc, iron, copper, boron and manganese were applied at 1000 ppm each, whereas molybdenum was applied at 50 ppm. All treatments significantly enhanced dry matter yield, fruit yield and nutrient uptake over the control.

Natesh *et al.* (2005) observed that foliar spray of micronutrients at flowering stage increased the plant growth. However, foliar spray of $ZnSO_4$ (0.1%) recorded more plant height (82.8cm), higher number of branches per plant (25.6) and also observed the influence organics (mycorrhiza, vermicompost and FYM) influenced the growth parameters significantly. Maximum plant height (73.7cm) and maximum number of branches per plant (21.3) was recorded in FYM (10 t ha^{-1}) followed by mycorrhiza (2.5 t ha^{-1}) (70.1 cm) and vermicompost @ 2.5 t ha^{-1} (69.3 cm and 20.9 cm) over control (68.9cm and 19.2cm). Foliar spray of micronutrients at flowering stage increased the growth and yield of chilli (*Capsicum annuum* L.) cv. Byadagi kaddi. Foliar spray of $ZnSO_4$ (0.1%) recorded higher yield (248.26 kg/ha) and quality parameters followed by borax and $MgSO_4$ (0.1% each).

Islam (2006) conducted an experiment at BINA farm, Mymensingh during 2005 to evaluate the effect of S, Zn and B on growth and nutrient uptake by BINA moog-5. The treatments were as NPK, NPK+S, NPK+Zn, NPK+B, NPK+S+Zn, NPK+S+B, NPK+Zn+B and NPK+S+Zn+B. Sulphur, zinc and boron were applied @ 20, 3 and 1 kg ha^{-1} from gypsum, zinc oxide.

Yadav *et al.* (2006) evaluated the effects of boron (0.0, 0.10, 0.15, 0.20, 0.25, 0.30 or 0.35%), applied to foliage after transplanting, on the yield of tomato cv. DVRT-1. The highest number of fruits per plant (44.0), yield per plant (0.79 kg) and yield/ha (31.95 mt) were obtained with 0.20% boron, whereas the greatest fruit weight (27.27g) was recorded for 0.10% boron.

Baloch *et al.* (2008) observed that HiGrow (commercial foliar fertilizer), a composition of various macro and micronutrients was applied on chilies at the concentrations 4, 5, 6, 7 and 8 ml L^{-1} water in addition to soil applied NPK fertilizers at 50-50-25 kg ha^{-1} to investigate their associative effect on production of green chilies. There was a consecutive improvement in growth and yield components of chilies with increase in HiGrow concentration, but such increase beyond 7 ml L^{-1} water was not so pronounced and hence 7 ml L^{-1} water was considered to be an optimum HiGrow concentration for commercial production of chilies.

Patil *et al.* (2008) showed the results based on two years mean that out of nine different treatments, the application of boric acid @ of 100ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha) followed by best treatment was the mixture of micronutrients (B, Zn, Mn and Fe @ 100ppm and Mo @ 50ppm) recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments.

Habib M. (2009) found that foliar application of Zn and Fe increased seed yield of wheat and its quality, compared with control. Among treatments, application of (Fe + Zn) obtained highest seed yield and quality.

Deore *et al.* (2010) revealed the consistent and significant results for growth parameters of chilli due to application of novel organic liquid fertilizer. Out of five different treatments, the 3% treatment resulted in maximum, plant height;

number of branches per plant, leaf number, leaf area, fresh and dry weight of the plant, number of fruits per plant and total yield.

Nasiri *et al.* (2010) showed that flower yield increased by foliar application of Fe and Zn compared with control (untreated). The highest flower yield (1963.0 kg ha^{-1}),was obtained for Fe + Zn spray treatment with about 46.4, 24.64, and 81.77% improvements in comparison with control, respectively. The results showed that flower yield and yield increased by foliar application of Fe and Zn compared with control (untreated). The highest flower yield (1963.0 kg ha^{-1}) was obtained for Fe + Zn spray treatment with about 46.4, 24.64, and 81.77% improvements in comparison with control, respectively.

Salam *et al*. (2010) found the highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), acidity (0.47%), ascorbic acid (10.95 mg/100g), lycopene content (112.00 μg/100g), chlorophyll-a (41.00 μg/100g), chlorophyll-b (56.00 μg/100g), marketable fruits in tomato at 30 days after storage (67.48%) and shelf life (16 days). The results were recorded with the combination of 2.5 kg B+ 6 kg Zn/ha and recommended dose of NPK fertilizers (N= 253, P= 90, and K= 125 kg/ha).

Zeidan *et al.* (2010) reported that grain yield, straw yield, 1000-grain weight and number of grains/spike, Fe, Mn and Zn concentration in flag leaves and grains as well as, protein content in grain were significantly increased by application of these elements in wheat.

Hamayun *et al.* (2011) conducted an experiment to evaluate the effect of foliar and soil application of nitrogen, phosphorus and potassium (NPK) on yield component of lentil (*Lens culinaris* Medic). Results showed that optimal concentration of NPK for the various yield parameters was found to be 0.17% N, 0.21% P and 0.33% K for foliar and 0.35% N, 0.32% P and 0.50% K for soil application at pH 7.0.

Khosa *et al.* (2011) reported that plant height, number of branches per plant, length of branches per plant, number of leaves per plant, leaf area, flower diameter and flower quality increased with increasing fertilization level and began to turn down when fertilization level exceed beyond the above given levels of macro and micro nutrients. Foliar fertilization influenced the days to first flower emergence as compared to control where no foliar spray of macro and micro nutrients was applied. It took 85.55 days in T_3 treatment as compared to control *i.e.* 105.55 when macro nutrients spray applied and in case of micro nutrients it took 81.88 days in flower emergence as compared to control *i.e* 100.88.

Roosta *et al.* (2011) showed that biomass gains of tomatoes were higher in hydroponics as compared to aquaponics. Foliar application of K, Mg, Fe, Mn, and B increased vegetative growth of plants in the aquaponics. In the hydroponics, foliar application of K, Mg and Zn increased fruit number and yield of plants compared to control. These results indicated that foliar application of some elements can effectively alleviate nutrient deficiencies in tomatoes grown on aquaponics.

Wahdan *et al.* (2011) conducted an experiment to study the effect of some chemicals on growth, leaf mineral contents, flowering, fruiting, yield and fruit quality of "Succary Abiad" mango cv. Fruit firmness and TSS were increased within all treatments with significantly increments than control. Vitamin C was significantly increased in fruits harvested from trees sprayed with $CaCl_2$ % after full bloom. Total sugars in the fruits significantly increased higher than control within all treatments.

Abedin *et al.* (2012) found significant results in most of the yield contributing parameters of onion like in leaves plant^{-1}, plant height, fresh weight of leaves, diameter of bulb and bulb yield of onion. The maximum yield and yield contributing parameters of onion i.e. leaves plant^{-1}, plant height, diameter of bulb, fresh weight of leaves and bulb yield were obtained from T4 but splitting of bulb in T_7 and fresh weight of roots in T_6.

Hasani *et al.* (2012) revealed that Mn sprays had positive significant effects on the fruit yield, the aril/peel ratio, TSS, weight of 100 arils, juice content of arils, anthocyanin index, fruit diameter and leaf area. Zn effects were also significant for TSS, TSS/TA ratio, juice content of arils and leaf area. According to the results, the suitable combination of these two micronutrients for studied characters of pomegranate under prevailing conditions was foliar spray of 0.6% $MnSO_4$ and 0.3% $ZnSO_4$.

Moghadam *et al.* (2012) revealed that different type of elements (Zinc, Boron and Copper) was significant on the number of spikes per plant, grain per spike, Grain in square meter, Harvest Index (HI %) and Grain yield (kg/ha) but had no effect on thousand grain weigh. Boron and Zinc showed higher amounts in mentioned traits than Copper, although Boron in Chenaran, and Zinc in Mashhad were more effective. the number of spikes per plant, Grain in square meter, and Grain yield increased with raising in Doses of foliar application, so that highest of these were in dose of 2 lit ha^{-1}.

Mia (2012) revealed that Boron (B) significantly influenced the growth, yield, size, shape and nutrient contents of three varieties of tomato. Growth parameters like plant height, number of fruits $plant^{-1}$, fruit size (fruit diameter), number of deformed fruit $plant^{-1}$, yield $plant^{-1}$ and nutrient contents of tomato fruits such as N, P, K, Ca, Mg, S, Zn, B and biochemical constituent as pH, total soluble solids and vitamin-C were significantly influenced due to the addition of B. The overall results suggest that treatment B_2 (2 kg ha^{-1}) along with recommended dose of NPK was the best on BT-14 followed by BT-7 for cultivation.

Sayed *et al*. (2012) investigated that high levels of phosphorus may decrease the availability of zinc or the onset of zinc deficiency associated with phosphorus fertilisation may be due to plant physiological factors. Higher concentrations of copper in the soil solution, relative to zinc, can reduce the availability of zinc to a plant (and vice versa) due to competition for the same sites for absorption into the plant root. Zinc deficiency is led to iron (Fe) deficiency, due to prevention of transfer of Fe from root to shoot in zinc deficiency conditions.

Shehata *et al.* (2012) showed that foliar application with yeast and chitosan increased significantly the vegetative growth, yield and its quality of cucumber. It can be concluded that foliar application with chitosan at rates of 4 ml L^{-1} recorded the best treatment to obtain the highest vegetative growth, yield and quality of cucumber plants.

Soleymani *et al.* (2012) showed that Fe, Zn and Mn had positive effect on yield and quality of forage sorghum. The highest plant height, LAI, Fresh forage yield, dry leaf and stem yield, total dry yield and dry leaf weight/dry stem weight was obtained in Zn+Fe+Mn application. On the basis of the results, it seems that application Zn+Fe+Mn was suitable to gain high forage yield and gain to high quality.

Ali *et al.* (2013) carried a field experiment to evaluate the possible effect of some macro and micro nutrients with different concentration levels as a foliar application on the vegetative growth, flowering, and yield of tomato cv 'Roma'. All the treatments showed a positive effect on growth, flowering, and yield but, T_5 (nitrogen 5.5 g/100 mL + Boron 5 g/100mL + Zinc 5 g/mL) and T_3 (Boron 5 g/mL), revealed most significant influence on all parameters under study as compared to T_1 (control).

Akbari *et al.* (2013) showed that Zn + Fe foliar application in cumin had significantly effects on yield and yield components such as number of umbels per plant, number of umbellets per umbel and 1000 seed weight. Zn + Fe foliar application had significant effect (a > 0.05) on most physiological traits in dry farming such as relative water content (RWC), and protein content. The results indicated that the foliar application of macronutrients caused a significant and/or highly significant effect on some of growth parameters and yield components during the two growing seasons. In addition, some nutrient of wheat grains content *i.e.* Potassium, Zinc, Manganese and Cupper were significant and or highly significant increased due to foliar application of macronutrients (El-Ghany, 2013).

Kazemi (2013) showed that high Zn (100 mg/L) and Fe (200 mg/L) and their combination significantly promoted vegetative and reproductive growth in tomato. Foliar application of Zn (100 mg/L) + Fe (200 mg/L) resulted in the maximum plant height (124.14 cm), branches per plant (8.36), flowers per cluster (18.14), fruits per cluster (8), fruits per plant (90.14), fruit weight (95.14 g), chlorophyll content (22.14 SPAD)and yield (25.14 t ha^{-1}). Results showed that in the cultivars stem diameter, number of seeds per plant, number of bolls, plant height and harvest index. Mn spraying and Zn + Mn spraying had maximum grain yield, biological yield, 1000- seeds weight, stem diameter, number of seeds per plant and plant height (Rajabi *et al.*2013).

Sivaiah *et al.* (2013) found in tomato all the treatments (treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control) resulted in improvement of plant growth characteristics viz. plant height, number of primary branches, compound leaves, tender and mature fruits per plant in both the varieties out of which application of micronutrients mixture showed the maximum effect. In tomato cv. UtkalKumari, maximum growth rate (85.7%) was observed with application of zinc, followed by application of micronutrients mixture (78.2%) and boron (77.5%). Tomato cv. Utkal Raja, maximum increase in branches per plant was observed with the application of manganese (148.7%) followed by micronutrient combination (144.1%). In UtkalKumari, the fruit yield per plant ranged from 1.336 kg to1.867 and in Utkal Raja, it ranged from 1.500 kg to 1.967 kg. Combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc. Application of micronutrients mixture showed the maximum effect.

Younis *et al.* (2013) reported that plants treated with foliar application of micro nutrients along with NPK showed significant increase in the growth characteristic like plant height, number of flowers plant^{-1}, bud diameter, flower diameter, fresh and dry weight of flower, flower quality, flower stalk length compared to the application of NPK alone and untreated plants (control). It was concluded that application of micronutrients along with NPK could improve flower yield and quality of roses.

Kashif *et al.* (2014) conducted an experiment, results regarding growth and yield showed a significant response to the foliar application of macro and micro-nutrients. It is confirmed from the results that combination of macro and micro-nutrients as foliar application enhanced the growth and yield of *Dahlia hybrida* positively.

Khan *et al*. (2014) showed that nitrogen levels had significant effect on all growth and yield parameters of chilli. Nitrogen application at the rate of 180 kg ha^{-1} significantly affected plant height (68.3 cm), number of leaves plant^{-1} (294), number of branches plant^{-1} (18.3), stem thickness (2.43 cm), fruits plant^{-1} (59.4), fruit length (6.83 cm), seeds fruit^{-1} (152) and yield (8.803 tons ha^{-1}). The maximum number of fruits plant^{-1} (47.7), fruit length (5.76 cm), seeds fruit^{-1} (109) and higher yield (7.102 tons ha^{-1}) were recorded with 50 kg K ha^{-1} which was statistically at par with 40 kg K ha^{-1} except for fruit length.

Rahman *et at.* (2014) showed that foliar feeding of micronutrients (B+ Mo + Zn) as combined application significantly increased the plant height, number of branches plant^{-1}, number of pods plant $^{-1}$, number of seeds pod $^{-1}$, biological and seed yields, while control (H_2O spray 2 alone) gave the minimum value in all the traits. Thus the study suggested that foliar application of micronutrients (B+ Mo + Zn) is beneficial to get the maximum seed yield of common bean.

Shnain *et al.* (2014) found (nine treatments with following combination of which was T_1-control,T_2- Zn 1.25 g/L, T_3- Zn 2.0 g/L, T_4- B 1.25 g/L,T_5- B 1.25 g/L + Zn 1.25 g/L,T_6- B 1.25 g/L,T_7- B 2.0 g/L,T_8- B 2.0 g/L + Zn 1.25 g/L and T_9- B 2.0 g/L + Zn 2.0 g/L). The highest fruit weight (72.67 g) was recorded in T6 and the highest plant height (2.93) m, no. leaves per plant (39.33) leaves, no. clusters per plant (12.33), no. fruits per cluster (7.17), no. fruit per plant (88.33), yield per plant (6.33 kg), total yield (113.628 t /ha), shelf life (26.33 days), total soluble solid (0Brix) (5.67) ,Vitamin C (32.57 mg / 100 g) and benefit: cost ratio (4.05 was obtained in T_5 treatment under Allahabad agro climatic conditions in tomato.

Jamal Uddin (2014) found that (experiment consisted of different liquid nutrient solutions with F_0 - control, F_1 -calsol, F_2 -wuxal and F_3 -flora) the longest pseudobulb (53.6 cm), maximum girth of pseudobulb (19.1 mm), number of pseudobulb (16.9), number of leaves (4.4/pseudobulb), leaf area (207.7 cm^2), length of spike (39.9 cm) and diameter of spike (24.3 mm) were found from F_2 which were statistically similar with F_3 but maximum number of spike (14.8 plant^{-1}), girth of spike (7.7 mm), number o f floret (10.3 spike^{-1}) and diameter of floret (10.0 cm) was found from F_3 which were statistically similar with F_2 while minimum from control in Dendroleium.

Zarghamnejad (2015) showed that the interaction of various levels of ferrous sulfate and manganese sulfate on tomato had significant effect on measured traits (root fresh weight, shoot fresh weight, shoot dry weight and fruit fresh weight) .Also, these increased compared with control. Based on the findings of this study, interaction of factors indicated the best results.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter illustrates information concerning methodology that was used in the accomplishment of the experiment. It includes a short description of experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure, and statistical analysis etc.

3.1 Experimental sites

The experiment was executed at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from October 2013 to July 2014. Location of site is $23^{o}74'$ N latitude and $90^{0}35'$ E longitude with an elevation of 8 meter from sea level (UNDP-FAO) in Agro- Ecological Zone of Madhupur Tract (AEZ 28).

3.2 Climatic conditions

Experimental site was located in the subtropical monsoon climatic zone, heavy rainfall occurred during the months of April to September (*kharif* season) and scantly of rain fall during the rest of the year (*rabi* season). Moderately low temperature and plenty of sunshine prevail during October to March (Rabi season), which is suitable for chilli cultivation in Bangladesh.

3.3 Soil of the experimental field

The soil of experimental area is situated to the Modhupur Tract (UNDP, 1988) under the AEZ 28 and Tejgoan soil series (FAO, 1988). The soil was sandy loam in texture with pH 5.47- 5.63.

3.4 Plant material

The local landrace chilli germplasms (Akashi, Kajoli, Deshi kacha morich, Bogra morich and Dongfou) were used in the present experiment. Chilli plants are mostly grown from the seed. The seed of chilli were collected from the local market in northern and southern part of Bangladesh.

3.5 Liquid fertilizers

Commercially available common liquid fertilizers were collected from local market in Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. It is a blend of more than one macro and micro nutrients.

Composition of liquid fertilizer

Chemical composition of the commercially available common liquid fertilizers

Name	Chemical composition
Calsol	N_2- 1.4%, K_2O-0.1%, Mg-0.71%, S-1.5%, Zn-0.12%, B-0.34%, Mo- 50 ppm, Mn-200 ppm with Ca and Fe.
Wuxal	N_2-8.0%, P_2O_5-8.0%, K_2O-6.0%, S-0.9%, Zn-0.005%, B-0.01%, Cu-0.007%, Mn-0.013%, Mo-0.001%, Fe-0.015%, Cl-0.9%

3.6 Seedbed preparation

The seedbed was prepared for raising seedlings of chilli 12 October' 2013 and the size of the seedbed was 4m × 2m. For making seedbed, to obtain good tilth the soil was well ploughed and converted into loose friable and dried masses. Stubbles and dead roots were removed. At the rate of 10 t ha^{-1} cow dung was applied to the prepared seedbed. To protect the seedlings plants from the attack of mole crickets, ants and cutworm soil was treated by seven 50 WP @ 5 kg ha^{-1}.

3.7 Seed treatment

To prevent some seed borne diseases such as leaf spot, blight, anthracnose, etc. seeds were treated by Vitavax-200 @ 5 g 1 kg^{-1} seed.

3.8 Seed sowing

Seeds were sown on 19 October, 2013 in the seedbed. Sowing was done thinly in lines spaced at 3 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by water can. Thereafter to maintain the required temperature and moisture the beds were covered with dry straw. The cover of dry straw was removed immediately after emergence of seed sprout. When the seeds were germinated, shade by bamboo mat (chatai) was provided over the seed bed to protect the young seedlings from burning sunshine and rain.

3.9 Raising of seedlings

Several times light watering and weeding were done. For raising of seedlings no chemical fertilizers was applied. Seedlings were not attacked by any kind of insect or disease. Thirty days old healthy seedlings were transplanted into the experimental field on 19 November, 2013.

3.10 Manuring and Fertilizing

Manure and fertilizers such as Cowdung, Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) and Gypsum were used as source of nitrogen, phosphorous, potassium and sulphur, respectively as recommended by BARI 2011.

Manure/ Fertilizer	Dose per hectare	Applied during land preparation	Applied after transplanting		
			1st installment at 25 DAT	2nd installment at 50 DAT	3rd installment at 70 DAT
Cowdung	10 ton	10 ton	-	-	-
Urea	210 kg	-	70kg	70 kg	70 kg
TSP	330 kg	330 kg	-	-	-
MOP	200 kg	65 kg	45kg	45	45kg
Borax	5 kg	-	-	-	-

3.11 Treatments in the experiment

The experiment was conducted to evaluation of local chilli germplasm to different commercially available liquid foliar fertilizers regarding morphophysiology, yield and quality. The experiment consist of two factors . They were as follows:

Factor A. Local chilli germplasms

In experiment, five different Local chilli germplasms were used. These were -

Akashi : V_1

Kajoli : V_2

Deshi kacha morich : V_3

Bogra morich : V_4

Dongfou : V_5

Factor B. Common liquid fertilizers

In experiment, three different commercially available liquid fertilizers were used. These were -

Control : F_0

Calsol : F_1

Wuxal : F_2

There were altogether 15 (5 x 3) treatments combination used in each block were as follows: V_1F_0, V_1F_1, V_1F_2, V_2F_0, V_2F_1, V_2F_2, V_3F_0, V_3F_1, V_3F_2, V_4F_0, V_4F_1, V_4F_2, V_5F_0, V_5F_1, V_5F_2.

3.12 Preparation and application of treatments

F_1 (Calsol) and F_2 (Wuxal) were applied @ 21 ml per 7 litre water for 168 m^2 of land at every 15 days interval. Foliar application was started from 30 days after setting up the experiment and continued up to 120 days. A hand garden sprayer was used to spray foliar fertilizer solution. Foliar fertilizers were applied on leaves at evening, because of less sun light, low transpiration and evaporation rate, absorbing more nutrients over night by the plant and beneficial pollinating agents are absent or return to their hive and also save to them from there nutrients.

3.13 Experimental design and lay out

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. The unit plot size was 1.5 m x 1 m. Distances between block to block and plot to plot were 1.0 and 0.5 meter, respectively. Plant to plant and row to row distance were maintained as 40 cm for each case.

3.14 Land preparation

The land of the experiment site was first opened in last week of October 2013 with power tiller. Later on, the land was ploughed and cross-ploughed three times followed by laddering to obtain the desire tilth. The corners of the land were spaded and larger clodes were broken into smaller pieces after ploughing and laddering all the stubbles and uprooted weeds were removed and land was made ready.

3.15 Transplanting

To minimize the damage of roots seedbed was watered before uprooting the seedlings. Care was taken at the time of uprooting so that root damage became less and some soil remained with the roots. Thirty days-old healthy seedlings were transplanted 19 November 2013 at the spacing of 40 cm × 40 cm in the experimental plots on 19 November 2013. Thus the 16 plants were accommodated in each unit plot. Planting was done in the afternoon. Light irrigation was given immediately after transplanting around each seedling for their better establishment. The transplanting seedlings were shaded for five days with the help of news paper to protect them from scorching sunlight watering was done up to five days until they became capable of establishing on their own root systems.

3.16 Intercultural operations

Gap filling

After transplanting some seedlings died and new seedlings from the same stock replaced these were planted in those place.

Weeding

The plants were kept under careful observation. Three times weeding were done during cropping period *viz.* 1^{st} December, 15^{th} December and 1^{st} January, for proper growth and development of the plants.

Spading

After each irrigation, soils of each plot were pulverized by spade at proper moisture condition for easy aeration.

Irrigation

Irrigation was given by observing the soil moisture condition. Five times irrigation were done during crop period on 4^{th} December, 16^{th} December, 24^{th} December, 5^{th} January, 15^{th} January and continued up to final harvesting for proper growth and development of plants.

Earthing up

Earthing up was done by taking the soil from the space between the rows on 2’ December 2013.

Insects and disease control

The scheme of plant protection measures against the disease and pests during the period of research was as follows.

Chemical	Dosage	Against (pest/disease)
1. Pyrifos 20 EC (soil drenching)	@ 2 ml l^{-1}	Cut worms
2. Confidor 70 WG	@ 0.7 gm l^{-1}	Sucking pests
3. Malathion 57 EC	@ 25 ml l^{-1}	Aphid
4. Bencarb 50 WP	@ 2.0 g l^{-1}	Fruit rot

Harvesting

Depending on the maturity mature green fruits were harvested at weekly intervals. Harvesting was started at 65 days after transplanting (DAT) and continued till 175 DAT.

3.17 Parameters

Five plants were selected at randomly from each unit plot and data were collected from each plot and mean data on the following parameters were recorded.

i. Crop growth characters

- Plant height (cm)
- Branches plant^{-1}
- Leaf plant^{-1}
- Leaf area (cm^2)
- Chlorophyll content (SPAD values)
- Days to flower bud initiation after transplanting

ii. Fruit characters

- Flowers plant^{-1} (counting up to 60 days after first flowering)
- Fruits plant^{-1}
- Fresh weight of 50-fruits (g)
- Dry weight of 50-fruits (g)
- Single fruit fresh weight (g)
- Fruit diameter (mm)
- Fruit length (mm)
- 1000 seed weight (g)
- Vitamin-C content in green chilli fruits (mg per 100 g fruit)
- Vitamin-C content in dry chilli fruits (mg per 100 g fruit)
- Protein contain in chilli fruits (% per 100 g fruit)

iii. Yield

- Yield plant^{-1} (g)
- Fresh fruit yield (t ha^{-1})

3.18 Collection of experimental data

In the net plot area, treatment wise five plants were randomly selected and tagged for recording biometric as well as yield observations. Growth parameters, *viz.*, Plant height (cm), number of branch Plant^{-1}, number of leaf plant^{-1}, were recorded at 45 to 85 DAT at 10 days interval.

3.18.1 Plant height

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

3.18.2 Branches plant^{-1}

Number of branches was counted from randomly five selected plants of each plot and average branches plant^{-1} was calculated.

3.18.3 Leaf plant^{-1}

Number of leaves was counted from randomly five selected plants of each plot and average leaves plant^{-1} was calculated.

3.18.4 Leaf area Measurement

By destructing method using CL-202 Leaf Area Meter (USA) leaf area was measured. Mature leaf from middle portion of the plant (above 20cm from ground level) were measured all time and expressed in cm^2. Then the mean was calculated.

3.18.5 Measurement of chlorophyll content

Leaf chlorophyll content was measured by using chlorophyll meter SPAD-502 plus (%). The chlorophyll content was measured 4 times from leaf tip to the leaf base and then averaged for analysis.

3.18.6 Days to flower bud initiation after transplanting

Days to flower bud initiation (*visual observation*) was counted the days from the date of chilli germplasm transplanting.

3.18.7 Flowers plant^{-1} (counting up to 60days)

Flowers of five randomly selected plants of each replication were counted and then the average number of flowers for each plant was determined. It was done continued up to two months at every single day interval from the first flower.

3.18.8 Fruits plant^{-1}

Fruits of five randomly selected plants of each replication were counted and then the average number of fruits for each plant was determined. It was done continued up to final harvesting.

3.18.9 Measurement of single fruit fresh weight

Fruit weight was measured by Electric Precision Balance in gram (g).Ten randomly fruits from each of the treatment were weighed and then divided by ten to get single individual fruit fresh weight.

3.18.10 Measurement of fruit length and diameter

Fruit length and diameter were measured using Digital Caliper-515 (DC-515) in millimeter (mm). Mean was calculated for each treatment.

3.18.11 Measurement of fresh weight and dry weight of 50-fruits (g)

Fresh weight and dry weight of 50-fruits were measured by Electric Precision Balance in gram (g). Fifty randomly selected fresh fruits from each treatment were weighed and dry in room temperature. Then fifty dry fruits were weighed.

3.18.12 1000 seed weight (g)

1000 seed weight was measured by Electric Precision Balance in gram (g). One thousand seeds from each treatment were counted then weighed.

3.18.13 Yield plant^{-1} (g)

Fruit weight of five randomly selected plants of each replication were weighed by using Electric Precision Balance in gram (g).Then average weight of fruit for each plant was determined. It was done continued up to final harvesting.

3.18.14 Fresh fruit yield (t ha^{-1})

Total weigh of fruits per plot (16 plants) were weighed by using Electric Precision Balance in gram (g) and it was done continued up to final harvesting. Then per plot yield was converted to per hectare yield.

3.18.15 Vitamin C contain in green and dry chilli

2, 6 - dichlorophenol indophenols (visual titration method) determined vitamin C content of green and dry fruits of chilli as described by Plummer (1971). For the estimation of vitamin C the following reagents were used.

Reagents

i. **3% Metaphosphoric acid (HPO_3) -** It was prepared by dissolving 30 g of HPO_3 and 80 ml glacial acetic acid in distilled water and one liter volume was made up.

ii. **Standard ascorbic acid solution -** By dissolving ascorbic acid in 3% metaphosphoric acid solution was made 10% of L- ascorbic acid solution was made.

iii. **Dye solution -** It was prepared by dissolving 260 mg of sodium salt of 2, 6 - dicholophenol indophenol in one liter of distilled water.

Procedure

Standardization of dye solution

Five ml of Meta phosphoric acid was diluted with 5 ml of standard ascorbic acid solution. A micro burette was loaded with dye solution and the mixed solution was titrated with dye solution using phenolphthalein as indicator to the pink colored end point which lasted for at least 15 sec. Dye factor was calculated using the following strand:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample

In a 100 ml beaker, five grams of fresh fruit and dry fruits of chilli was taken with 50 ml 3% metaphosphoric acid and then it was transferred to a blender and homogenized with same concentration of metaphosphoric acid. After blending then it was filtered and centrifuged at 2000 rpm for 5 minutes. In 100 ml volumetric flask homogenized liquid was transferred and volume was made up to the mark with 3% metaphosphoric acid.

Titration

In a conical flask 5 ml of the aliquot was taken and titrated with 2, 6-dicholophenol indophenols dye, phenolphthalein was used as indicator to a pink colored end point, which persisted at least 15 seconds. The ascorbic acid content (Vitamin C) of the sample was calculated by using the following strand:

$$\text{Ascorbic acid (mg /100gm)} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre value (ml)

D = Dye factor

V_1= Volume to be made (ml)

V_2= Volume of extract taken for titration (ml)

W = Weight of sample taken for estimation (g)

3.18.16 Protein content of green chilli fruits

Micro Kjeldahl method was determined protein content. The accepted method was as follows:

Chemicals required

- Concentrated sulphuric acid
- Mixture of digestion
    - Potassium sulphate = 100 g
    - Copper sulphate = 20 g
    - Selenium di-oxide = 2.5 g
- Solution of Boric acid : 2% solution in water
- Solution of Alkali : In 1 litre of water 350 g sodium hydroxide dissolved
- Mixed indicator solution: In 100 ml ethyl alcohol 0.1 g Bromocresol green + 0.02 g methyl red dissolved
- Standard 0.01 N HCl

Procedure

Digestion

First, 5 g of sample was weighed then transferred in to the kjeldhal flask. About 5 g of digestion mixture with 20 ml of conc. sulphuric acid were added to the flask. By using an electric heater contents of the kjeldal flask were heated over in a digestion chamber up to the solution was cleared (bluish color).

Distillation

The flask was cooled carefully after digestion and with distilled water volume was made 100 ml. An aliquot 10 ml was taken along with 20 ml of 35 % of Sodium hydroxide in a distillation flask for distillation. In a conical flask 20 ml of boric acid solution and 1 drop of blend indicator were taken. In the conical flask, distillation apparatus was connected up with the delivery tube dipping below the boric acid solution. The distillation apparatus was switched on and then the ammonia was distilled of as drop from the distillation flask into the boric acid solution. Before the distillation apparatus was switched off, it was allowed until 10 minutes and from the conical flask delivery tube removed and washed down.

Titration

The collected ammonia was titrated with 0.1 N HCl solutions and titre value was recorded. To calculate the percent of protein in the sample using protein factor of 6.25. (Ranganna, 1977)

$$\text{Percent of } N_2 = \frac{(T_S - T_B) \times 14 \times \text{Volume made up}}{\text{Weight of sample} \times \text{aliquot sample taken for estimation} \times 500} \times 100$$

Where,

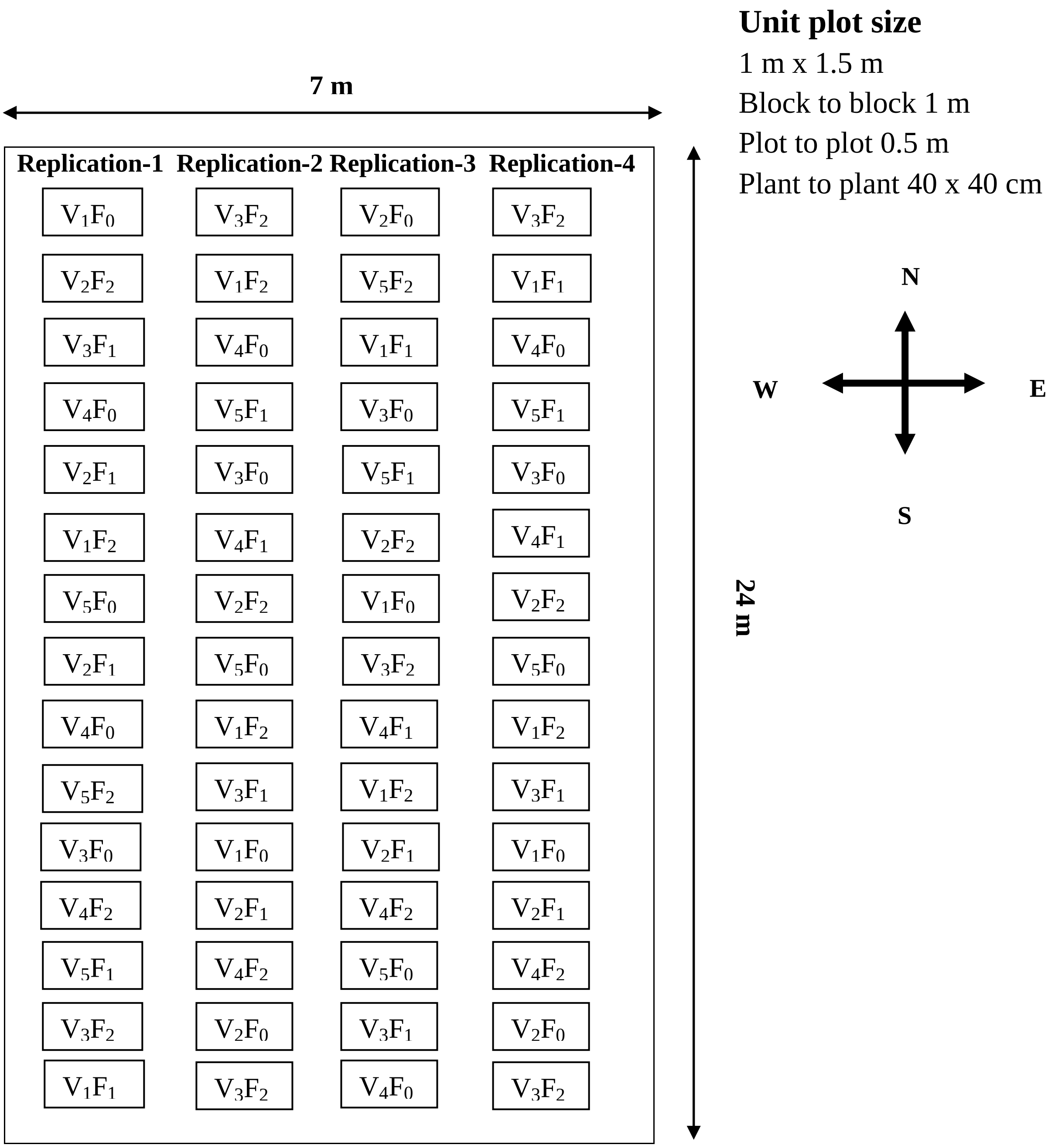
T_S = Titre volume of the sample in ml

T_B = Titre volume of the blank in ml

Percent of Protein = Percent of N_2 ×protein factor

3.19 Statistical analysis

To find out the significance of the experimental results data in respect of growth and yield components were statistically analyzed. All the treatments mean were calculated and for each of the characters the analysis of variance was performed by F test. The difference among the treatment means was evaluated by Least Significant Difference (LSD) test (Gomez and Gomez, 1984) at 5% level of probability.

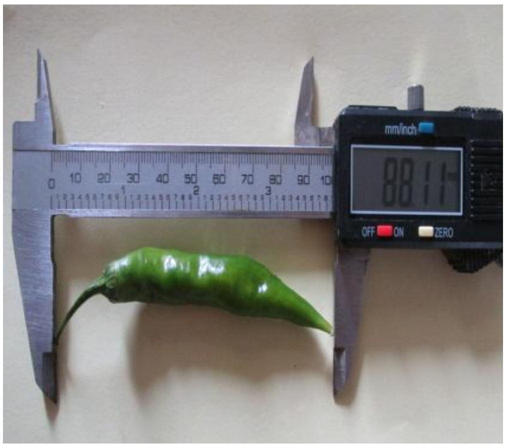


Factor: A
V_1, Akashi
V_2, Kajoli
V_3, Deshi kacha morich
V_4, Bogra morich
V_5, Dongfou

Factor: B
F_0, Control
F_1, Calsol
F_2, Waxul

Plate 1. Layout of the experiment al field

a. b.

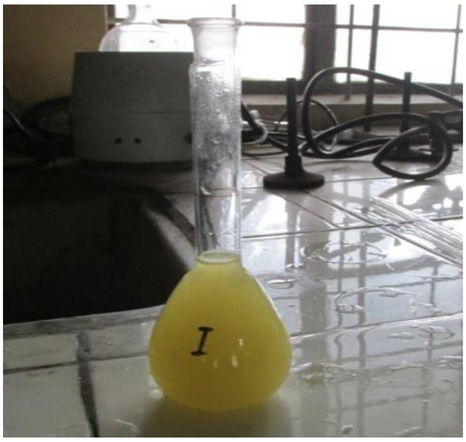


c. d.

e. f.

Plate 2: a. Plant height measurement by using meter scale in cm **b.** Fruit weight measurement by using Electronic Precision Balance in gram (g). **c.** Fruit diameter measurement using Digital Caliper-515 (DC-515) in millimeter (mm). **d.** Fruit length measurement using Digital Caliper-515 (DC-515) in millimeter (mm). **e.** Measurement of leaf chlorophyll content by using SPAD. **f.** Leaf area was measured by using CL-202 Leaf Area Meter (USA).

a. Weighting **b. Blending**



c. Filtering **d. Sampling**

e. Transfer in to flask **f. Titration**

Plate 3. General procedure of estimating vitamin C in chilli fruits.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULT AND DISCUSSION

The research work was accomplished for the evaluation of local germplasm of chilli to different liquid fertilizers regarding morphophysiology, yield and quality. Crop characteristics differed among the germplasm due to their genetic variation. Five chilli germplasms were evaluated on the experiment that was differentiated in terms of morphological characters, yield and quality.

4.1 Morphological variations in five chilli germplasm

	Germplasm				
	V_1	**V_2**	**V_3**	**V_4**	**V_5**
Stem colour before transplanting	Green	Purple	Green	Green	Green
Stem Shape (mature plant)	Angled	Cylindrical	Cylindrical	Cylindrical	Angled
Stem pubescence (mature plant)	Dense	Intermediate	Sparse	Sparse	Sparse
Plant growth habit	Erect	Erect	Intermediate	Erect	Erect
Leaf density	Dense	Sparse	Intermediate	Intermediate	Sparse
Leaf color	Dark green	Purple	Light Green	Green	Green
Leaf pubescence	Dense	Intermediate	Sparse	Sparse	Sparse
Number of flower per axil	One	Two	One	One	One
Flower position	Erect	Intermediate	Erect	Intermediate	Pendant
Corolla color	White	Purple	White	White	White

Characteristics	Germplasm				
	V_1	**V_2**	**V_3**	**V_4**	**V_5**
Anther colour	Pale blue	Purple	Pale blue	Pale blue	Pale blue
Calyx margin	Intermediate	Dense	Intermediate	Intermediate	Dense
Calyx annular constriction	Present	Present	Present	Present	Present
Fruit color at intermediate stage	Green	Purple	Green	Yellow	Yellow
Fruit set	High	High	High	Intermediate	Low
Fruit color at mature stage	Light Red	Light Red	Pale orange	Red	Light red
Fruit shape	Elongated	Elongated	Elongated	Elongated	Blocky
Neck at base of fruit	Absent	Present	Absent	Absent	Present
Fruit Surface	Smooth	Semi wrinkled	Smooth	Semi wrinkled	Smooth
Seed Color	Straw	Brown	Straw	Straw	Straw

V_1, Akashi ; V_2, Kajoli ; V_3, Deshi kacha morich ; V_4, Bogra morich ; V_5, Dongfou

V_1 V_2 V_3 V_4 V_5

Plate 4a. Mature leaf variation of five local chilli germplasm

Plate 4b. Flower petal and color are differentiation of chilli germplasm

Plate 4c. Variation in flower position of local chilli germplasm

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V_1, Akashi ; V_2, Kajoli ; V_3, Deshi kacha morich ; V_4, Bogra morich ; V_5, Dongfou.

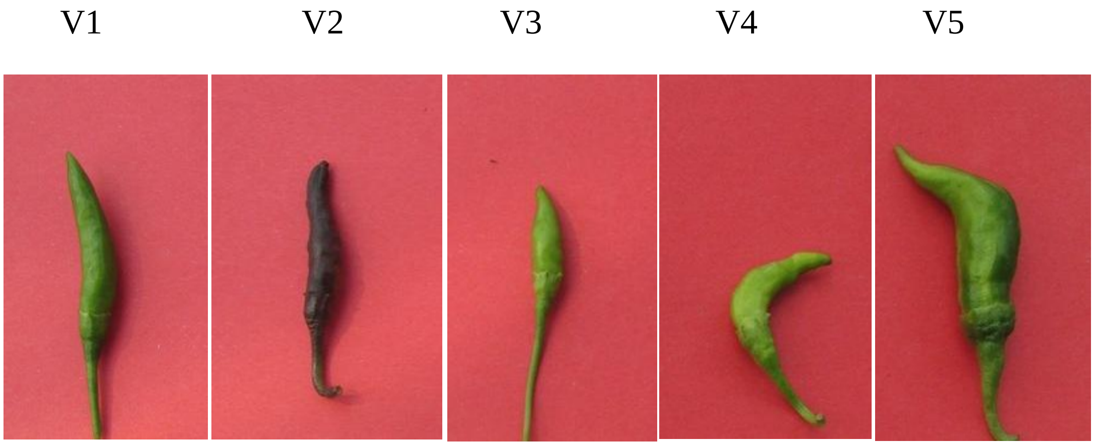

Plate 4d. Variation in fruit length, shape (immature) of chilli germplasm

Plate 4e. Fruit color, fruit surface and length inequality of chilli germplasm

Plate 4f. Variation in fruits position of chilli germplasm

V_1, Akashi ; V_2, Kajoli ; V_3, Deshi kacha morich ; V_4, Bogra morich ; V_5, Dongfou.

4.2 Plant height

Significant variation in plant height was observed with different chilli germplasms *viz.* (V_1 , Akashi; V_2 , Kajoli; V_3 , Deshi kacha morich; V_4 , Bogra morich; V_5 , Dongfou) at 45, 55, 65, 75 and 85 DAT (Appendix I). Maximum plant height was scored from V_2 (59.5 cm). Minimum from V_4 (50.7 cm) at 85 DAT (Fig. 2) i.e., Kajoli produced maximum plant height. Chowdhury *et al.* (2015) found that plant height of four chilli cultivars. There was a lot of variation in height of Capsicum plants obtained by Hosmani (1982). High phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were found for plant height obtained by Mini and Khader (2004); Sreelathakumary and Rajamony (2004); Ukkund *et al.* (2007) and Singh *et al.* (2009).

Plant height of local chilli germplasms exposed to liquid fertilizers showed statistically significant inequality among control, calsol and waxul at 45, 55, 65, 75 and 85 DAT (Appendix I). Maximum plant height was counted in calsol (F_1; 59.5 cm) treated plants where as minimum in control (F_0; 57.0 cm) that is statistically similar with F_2 at mature stage (Figure 3). According to Kashif *et al.* (2014) plants which were fertilized with macro and micro-nutrient solutions increased their height as compared to control treatment. Scagel *et al.* (2007) found that increase in plant height with boost up in nutritional level of macro nutrients i.e. NPK up to certain level and lowering the levels of macro nutrients taking more time and give less production. Similar result obtained by Hatwar *et al.* (2003) was the effect of foliar application of micronutrients along with the recommended dose of fertilizer. They reported that the combined spraying of Zinc, Boron and Iron each @ 0.1 per cent along with recommended dose of NPK @ 150:50:50 resulted in maximum height of the plant (70.36 cm). Foliar application of N, P, K, Ca, Mg and Fe, B, Zn, Mn and Cu and resultantly these nutrients were established in leaves, indicating the possibility of reducing the application of nitrogen fertilizers (Radulovic, 1996).

Effect of different different treatments on chilli germplasms in terms of plant height also exposed significant variation. Plant height of chilli germplasms were observed significant inequality among treatments at 45, 55, 65, 75 and 85 DAT (Appendix I). Maximum plant height (65.7 cm) was achieved from V_2F_1 treatment combination at all DAT. Whereas minimum (48.9 cm) from V_4F_0 treatment combination (Table 1). Similar result was obtained by Datir *et al*. (2012) who reported that chilli plant received foliar application of organic micronutrient chelate at the concentration of 2% resulted in maximum (60.1 cm) plants height. The results of the present investigation are also concurrence with Baloch *et al.* (2008) who applied foliar application of macro and micro nutrient solution ‘HiGrow’ that were established in leaves and increase plant height of chilli plant.

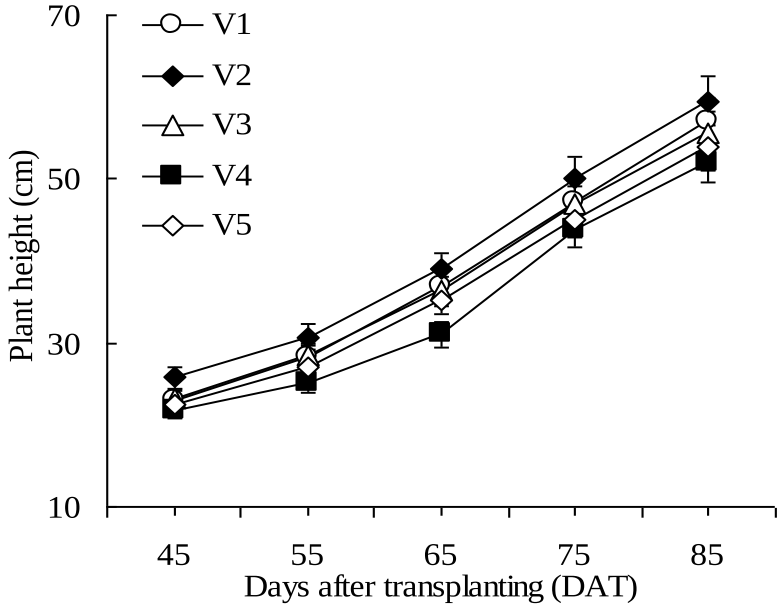

Fig. 1: Performance of chilli germplasm on plant height at different days after transplanting (DAT) (V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra morich ; V_5 , Dongfou).

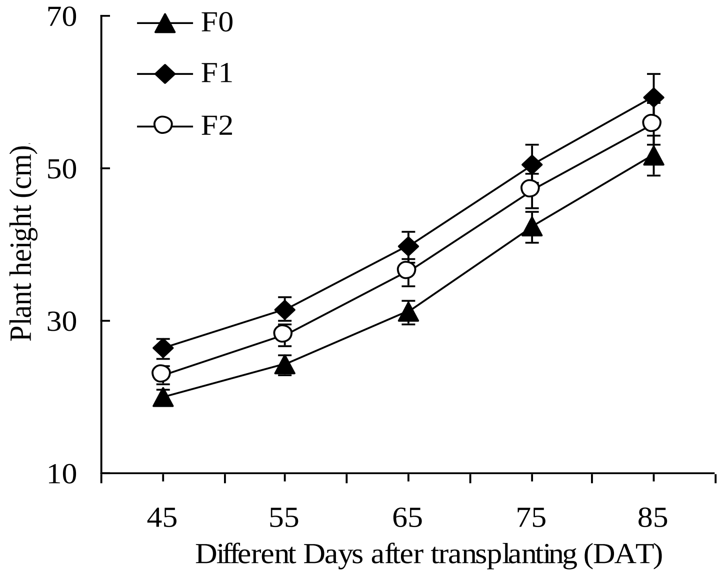

Fig. 2: Effect of foliar nutrient on plant height at different days after transplanting (F_0 , Control ; F_1 , Calsol ; F_2 , Wuxal).

Table 1. Effect of foliar fertilizers on the height plant of chilli germplasm at different days after transplanting (DAT)

Treatments[X]	45 DAT	55 DAT	65 DAT	75 DAT	85 DAT
V_1F_0	19.9 j	23.1 j	30.7 g	39.9 h	50.8 i
V_1F_1	26.4 b	33.7 b	42.4 b	52.8 b	62.6 b
V_1F_2	22.8 fg	28.2 efg	37.5 e	49.3 cd	57.7 d
V_2F_0	22.3 gh	26.1 hi	32.6 f	44.2 ef	53.1 gh
V_2F_1	28.9 a	36.0 a	45.7 a	55.9 a	65.7 a
V_2F_2	26.1 bc	29.9 d	38.9 cd	50.3 c	59.7 c
V_3F_0	20.8 i	25.1 i	32.6 f	42.4 fg	55.6 ef
V_3F_1	25.5 cd	31.3 c	39.3 c	50.4 c	59.9 c
V_3F_2	23.3 f	29.0 def	37.1 e	47.9 d	56.3 de
V_4F_0	19.5 j	23.1 j	28.8 h	43.4 efg	48.9 j
V_4F_1	24.3 e	27.1 gh	33.2 f	45.3 e	51.8 hi
V_4F_2	21.6 h	25.1 i	31.1 g	42.7 fg	51.4 hi
V_5F_0	19.7 j	23.5 j	30.8 g	41.5 gh	51.0 i
V_5F_1	24.9 de	29.4 de	37.9 de	48.4 cd	56.5 de
V_5F_2	23.0 fg	28.0 fg	37.0 e	45.1 e	54.0 fg
CV (%)	**2.2**	**3.1**	**2.4**	**3.3**	**2.2**
LSD (0.05)	**0.7**	**1.2**	**1.2**	**2.2**	**1.7**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

4.3 Branches plant^{-1}

Significant variation was found on number of branches among the different germplasms of chilli at 45, 55, 65, 75 and 85 DAT (Appendix II). Maximum number of branches (33.1) was obtained from Akashi (V_1) that ware statistically similar with V_2 and V_3. Minimum (18.6) was observed from Dongfou (V_5) at 85 DAT (Fig. 4). Smitha *et al.* (2006) observed significant differences among the germplasm with respect to both quantitative and qualitative characters. Similar result was reported by Ukkund *et al.* (2007).

Number of branches of chilli germplasms exposed statistically significant inequality among control, calsol and waxul at 45, 55, 65, 75 and 85 DAT (Appendix II). Maximum number of branches was counted in Calsol (F_1; 33.0) treated plants where as minimum in Control (F_0; 23.8) at mature stage (Fig. 5). This is in agreement with the report of Usha bala *et al.* (2006) in gladiolus. Hatwar *et al*. (2003) also reported that the combined spraying of zinc, boron and iron each @ 0.1 per cent along with recommended dose of NPK @150:50:50 caused maximum number of branches per plant.

Effect of macro and micro nutrient blend on chilli germplasms in terms of number of branches per plant also exposed significant variation (Appendix II). Number of branches of chilli germplasms was observed significant inequality among treatments at 45, 55, 65, 75 and 85 DAT. Maximum number of branches (43.0) was achieved from V_1F_1 treatment at 85 DAT. Whereas minimum from V_5F_0 treatment (14.5) (Table 2). Increase in plant height and number of branches per plant in chilli with commercial macro and micronutrient formulation “HiGrow” were reported by Baloch *et al*. (2008). The similar results were also reported by Malawadi (2003) by treating the chilli seedlings with micronutrients.

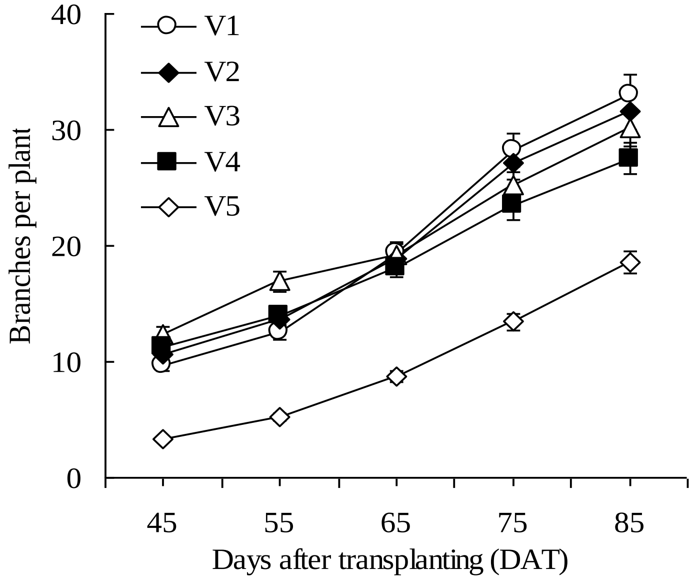

Fig. 3: Performance of chilli germplasm on branch plant^{-1} at different days after transplanting (V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra morich ; V_5 , Dongfou).

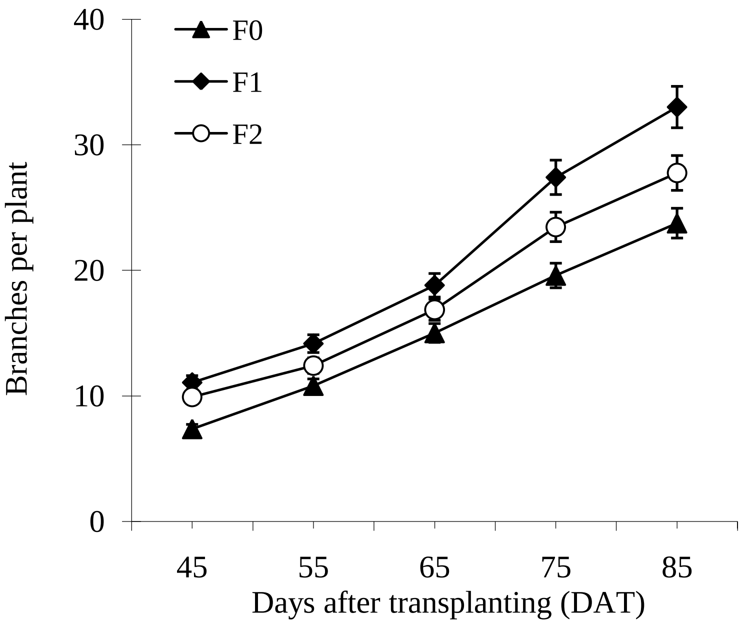

Fig. 4: Effect of foliar nutrient on branch per plant at different days after transplanting (F_0 , Control ; F_1 , Calsol ; F_2 , Wuxal).

Table 2. Effect of foliar fertilizers on the branches plant^{-1} of chilli germplasm at different days after transplanting (DAT)

Treatments^{X}	45 DAT	55 DAT	65 DAT	75 DAT	85 DAT
V_1F_0	6.3 e	10.3 e	15.8 f	21.8 ef	25.5 def
V_1F_1	12.0 ab	14.3 bcd	23.5 a	35.8 a	43.0 a
V_1F_2	10.8 bc	13.0 cd	19.0 bcd	27.3 bcd	30.8 bcd
V_2F_0	8.5 d	12.3 de	17.3 def	22.8 def	27.5 de
V_2F_1	12.3 ab	15.3 bc	20.8 b	31.8 ab	36.3 b
V_2F_2	11.0 bc	13.5 cd	18.5 cde	26.8 cd	31.0 bcd
V_3F_0	11.0 bc	15.0 bc	17.8 de	22.0 ef	26.8 def
V_3F_1	13.5 a	19.5 a	20.3 bc	28.5 bc	34.3 bc
V_3F_2	12.5 ab	16.3 b	19.8 bc	25.0 cdef	29.3 cde
V_4F_0	9.0 cd	12.5 de	17.5 def	20.6 f	24.5 efg
V_4F_1	13.5 a	16.3 b	20.0 bc	25.3 cde	29.8 cde
V_4F_2	11.3 b	13.0 cd	17.0 ef	24.5 cdef	28.3 de
V_5F_0	2.0 f	4.0 f	6.8 h	10.8 h	14.5 h
V_5F_1	4.0 f	5.5 f	9.5 g	15.8 g	21.8 fg
V_5F_2	4.0 f	6.3 f	10.0 g	13.8 gh	19.5 gh
CV (%)	**15.9**	**13.2**	**7.6**	**13.6**	**13.7**
LSD (0.05)	**2.1**	**2.4**	**1.8**	**4.6**	**5.5**

^{X} V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

^{Y} In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.4 Leaf plant^{-1}

Leaf number of chilli germplasms did not differ significantly between V_1 and V_2. But statistically significant among V_3, V_4 and V_5 germplasms at 45, 55, 65, 75 and 85 DAT (Appendix III). Maximum number of leaves was recorded from V_2 (84.1) that are statistically similar with V_1 and V_2. Minimum from V_5 (40.4) at 85 DAT (Fig. 6).

Improvement in growth characters such leaf number as by the application of nutrients may exist due to enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation (Hatwar *et al.* 2003). Leaves number of chilli germplasm exposed statistically significant inequality among control, calsol and waxul at 45, 55, 65, 75 and 85 DAT (Appendix III). Maximum leaf number was counted in F_2 (Calsol ; 78.4) treated plants where as minimum in F_0 (control ; 67.2) at mature stage (Fig. 7). Abedin *et al.* (2012) observed the similar observation and Kashif *et al.* (2014) also reported that application of macro and micro nutrients solution increased the number of leaves per branch compared to control. Singh and Tiwari, (2013) obtained increased number of leaves due to the foliar application of zinc (zn) and boron (B).

Effect of different liquid fertilizers on chilli germplasms in terms of leaf number also exposed significant variation (Appendix III). In case of leaf number of chilli germplasm was observed significant inequality among the treatments at 45, 55, 65, 75 and 85 DAT. Maximum number of leaves (90.0) was achieved from V_2F_1 treatment combination that was statistically similar with V_1F_1, V_2F_2 , V_3F_1 at 85 DAT where as minimum (35.5) from V_5F_0 treatment (Table 3). Findings are in tune with Deore *et al.* (2010) who found the similar results in chilli when treated with mixture of organic and inorganic fertilizers.

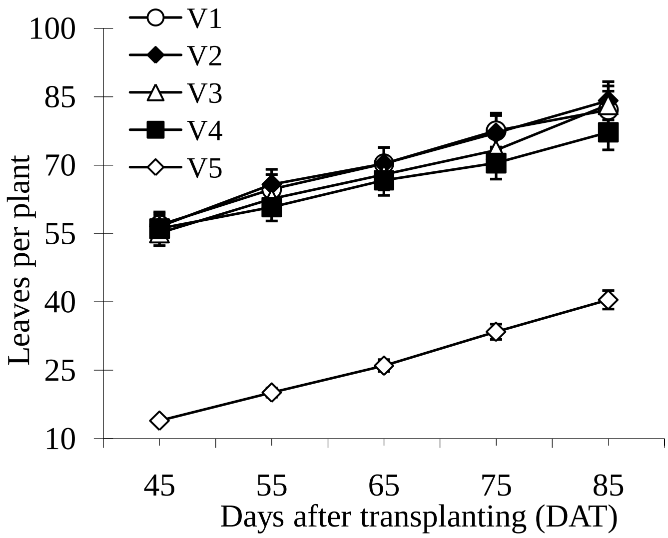

Fig. 6: Performance of chilli germplasm on leaves plant^{-1} of at different days after transplanting (V_1 , Akashi ; V_2 , Kajoli; V_3 , Deshi kacha morich; V_4 , Bogra morich; V_5 , Dongfou).

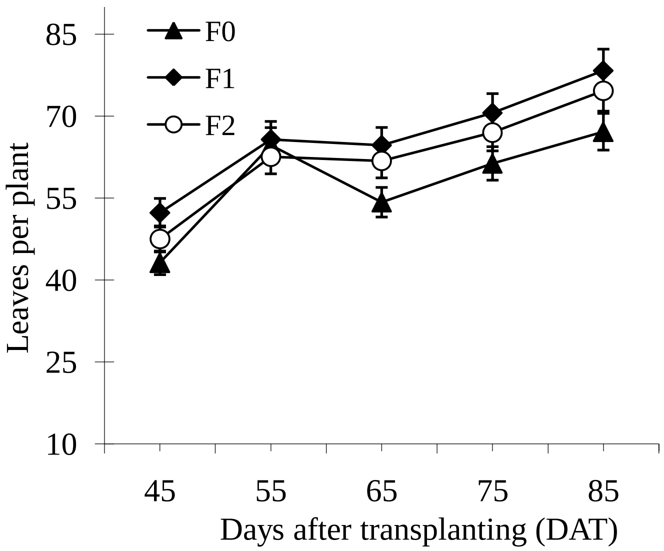

Fig. 7: Effect of foliar nutrient on leaves per plant at different days after transplanting (F_0 , Control; F_1 , Calsol; F_2 , Wuxal).

Table 3. Effect of foliar fertilizers on the leaf plant^{-1} of chilli germplasm at different days after transplanting (DAT)

Treatments[X]	45 DAT	55 DAT	65 DAT	75 DAT	85 DAT
V_1F_0	51.8 e	57.0 e	64.0 ef	70.8 f	73.8 g
V_1F_1	63.3 a	73.3 a	75.0 ab	82.5 a	89.3 a
V_1F_2	55.5 d	63.8 cd	72.0 bc	79. 3 ab	83.3 cd
V_2F_0	52.1 e	58.0 e	62.2 f	70.0 f	75.0 fg
V_2F_1	61.6 ab	74.0 a	76.0 a	82.8 a	90.0 a
V_2F_2	55.8 d	65.3 bcd	72.8 abc	78.3 bc	87.3 ab
V_3F_0	49.8 e	57.3 e	62.0 f	70.0 f	77.8 ef
V_3F_1	59.9 bc	67.5 bc	71.8 bc	76.3 bcd	87.3 ab
V_3F_2	55.6 d	63.0 d	70.0 cd	73.5 def	84.5 bc
V_4F_0	50.6 e	56.8 e	61.5 f	65.0 g	73.8 g
V_4F_1	60.8 ab	68.0 b	71.0 cd	75.0 cde	80.8 de
V_4F_2	56.8 cd	57.5 e	67.5 de	71.3 ef	77.0 fg
V_5F_0	11.5 g	15.8 g	21.5 h	31.0 i	35.5 i
V_5F_1	16.3 f	23.5 f	29.8 g	36.5 h	44.5 h
V_5F_2	14.0 fg	21.0 f	26.8 g	32.8 hi	41.3 h
CV (%)	**4.9**	**4.9**	**4.6**	**4.4**	**3.5**
LSD (0.05)	**3.3**	**3.8**	**3.9**	**4.1**	**3.7**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

4.5 Chlorophyll content (SPAD values) at mature stage

Significant variation was found on chlorophyll content (SPAD values) with different chilli germplasms (Appendix IV) at mature stage. Maximum chlorophyll content (56.9%) was obtained from V_2 (Kajoli) where as minimum (48.9%) was obtained from V_5 (Dongfou) at 85 days after transplanting. (Table 4). Chlorophyll content ranged from 60.9 to 52.8 studied among four chilli cultivars obtained by Chowdhury *et al.* (2015).

Chlorophyll content was showed the significant variation by different foliar fertilizer *viz.* F_0 , control; F_1 , calsol; F_2 , wuxal at 85 days transplanting (Appendix IV). Highest chlorophyll percentage (57.1%) was obtained from F_2 and lowest (49.5%) was reported from F_0 (Table 5). Mishra *et al.* (2003) also observed that citrus treated with zinc, iron and boron provide significant improvement in chlorophyll content. Kazemi (2013) also showed that combined application of micronutrient increase chlorophyll content in tomato leaf.

Chlorophyll percentage was statistically significant combination with local chilli germplasm along with interaction of different liquid fertilizers (Appendix IV) at mature stage. Difference of this significant was observed among highest chlorophyll percentage (60.9%) in V_2F_1 and lowest (45.7%) in V_5F_0 (Table 6).

4.6 Leaf area (cm^2)

Significant variation was observed among different chilli germplasm performance in terms of leaf area (Appendix IV) at 85 DAT. Leaf area of local chilli germplasm exposed statistically dissimilarity between V_3 and V_5 germplasms, where as statistically equality found in V_1 , V_2 , V_4 germplasms at 85 DAT (Appendix IV). Dongfou, (V_5) (125.8 cm^2) was accorded top most result in term of leaf area where as V_3 (Deshi Kacha Morich; 62.38 cm^2) was scored as inferior at 85 DAT (Table 4). According to Edwards *et al.* (1975)

unit leaf area is a valid basis for assessing the effects of short term fluctuations in environmental variables on photosynthesis.

Leaf area represents the foliage of plants that give excellent results after foliar spraying of macro and micro nutrients .The food prepares by leaves and maximum leaf area provides more food to body of the plant to keep it healthy. Leaf area was significantly affected by foliar fertilizer treatment directly to the leaf (Appendix IV). Leaf area of chilli germplasms exposed statistically significant inequality among control, calsol and wuxal at 85 DAT (Table 5). Maximum leaf area (95.9 cm^2) was marked in F_2 (Wuxal) treatment which was statistical similar with treatment F_1 (Calsol) (92.2 cm^2). Minimum leaf area (77.99 cm^2) was marked in F_0 (Control) treatment (Table 4). Maximum leaf area from macro and micro nutrients treatment and minimum from control treatment were also reported by Kashif *et al.* (2014). Jamal Uddin (2014) also found that leaf area was increased due to foliar application of nutrient solution (Wuxal). It composed of the essential macro and micro nutrients for the plants and thus may be responsible for improvement of these characteristics. Positive effect of foliar application of zinc and boron on leaf area to tomato plant (Ali *et al.* 2015).

Effect of different treatments on chilli germplasms in terms of leaf area also exposed significant variation (Appendix IV). Leaf area of chilli germplasms observed statistically significant inequality among treatments at 85 DAT. Maximum leaf area (132.6 cm^2) was achieved from V_5F_2 treatment thatwas statistically similar with V_5F_1 (128.0 cm^2) treatment, where as minimum from V_3F_0 treatment (49.67 cm^2) (Table 6).

4.7 Days to first flower bud initiation after transplanting
(*Visual observation*)

Significant variation in respect of days (from days after transplanting of chilli seedlings) taken for flower bud appearance (visual observation) was received among the germplasms (Appendix IV). Longest period was required for flower bud initiation in V_5 (61.1 days) whereas shortest period from V_4 (39.1 days) (Table 4). This result showed that V_4 was early flower bud initiating germplasm whereas V_5 was late one. Days to flower bud initiation and flowering are a basis for measuring the early or late cultivars. Days required to flowering in chilli crop mainly depend on the variety stated by Hosmani (1982), Veerapa (1980) and Ukkand *et al.* (2007).

Days to flower bud initiation was significantly affected by foliar fertilizer application (Appendix IV). Flower bud initiation was the earliest in control (F_0) (46.45 days) treated variety and delayed in calsol (F_1) (52.95 days) (Table 5). Appropriate time for flower bud initiation is important to plant because in this time maximum photosynthetic translocation occurs in vegetative part development. The fertilization level of micro nutrients improves the growth and productivity of plants. These results are similar with Sharaf and El-Naggar (2003), stated that carnation has greater response to foliar application of nutrients.

Foliar fertilizer application on local chilli germplasms affected significantly days taken to flower bud initiation from transplanting of chilli seedlings (Appendix IV). The treatment combination V_4F_0 (47.0 days) required minimum days for flower bud initiation whereas maximum days from V_5F_1 treatment combination (64.0 days) (Table 6).This delayed flowering under treatment was mainly associated with better plant growth and due to increasing growth period of the plants and delayed the flower emergence for few days. In case of control plots, the early flower emergence was associated with relatively weaker crop growth and due to reduced growth period, the flowering occurred earlier than those received treatment. Similar result showed that foliar spray of Zinc in chilli delay flowering and increase growth period of plant (Kalroo *et al.*, 2013).

4.8 Flowers plant^{-1} (Counting up to 60 days after first flowering)
(*Visual observation*)

Number of flowers per plant was significantly varied with local chilli germplasms (Appendix IV). Number of flowers was found highest in germplasm V_2 (81.00 plant^{-1}) whereas lowest in germplasm V_5 (24.6 plant^{-1}) (Table 4). In case of number of flowers Chilli cultivar was significantly different from one cultivar to another (Chowdhury *et al.* 2015; Veerapa, 1980; Hosmani, 1982) and Ruby King took 43 days for flowering, the sweet pepper variety flowered at 27 days after transplanting (Veerapa, 1980).

Different foliar fertilizers were significantly subjective on production of flowers per plant (Appendix IV). Calsol treated plants produced maximum number of flowers (F_1) (68.7 plant^{-1}) while minimum in control (F_0) (47.80 plant^{-1}) (Table 5). Ahmad *et al.* (2010) reported that maximum flowering plant^{-1} was found by providing micro-nutrients. Nutrient application compared with the control plants provided 14% greater numbers of flowers (Probhat and Arora, 2010; Sajid *et al.*, 2010). Foliar application of balance nutrition (Zn 6%), (B 5%), (N 2%) enhanced number of flower in tomato plant (Ejaz *et al.* 2011). Kazemi (2013) also observed that number of flowers in tomato plant was increased by combined application of micronutrient.

Foliar fertilizers application on local chilli germplasms affected significantly number of flowers per plant (Appendix IV). Maximum number of flower was found from V_2F_1 treatment combination (90.00) while minimum from V_5F_0 treatment combination (19.25 days) (Table 6).

Table 4. Growth related attributes of different chilli germplasm [Y]

Treatments[X]	Chlorophyll percentage (%) at mature stage	Leaf area (cm^2) at 85 DAT	Days to flower bud initiation after transplanting	Number of flowers $plant^{-1}$
V_1	54.8 ab	89.6 b	51.6 b	64.6 b
V_2	56.9 a	84.6 b	49.2 b	81.0 a
V_3	54.4 b	62.4 c	46.3 c	62.8 b
V_4	52.5 b	81.2 b	39.1 d	56.5 c
V_5	48.9 c	125.8 a	61.1 a	24.6 d
CV (%)	**5.3**	**11.8**	**6.7**	**7.5**
LSD (0.05)	**2.3**	**2.3**	**2.7**	**3.6**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 5. Effect of liquid fertilizers on the growth related attributes of chilli [Y]

Treatments[X]	Chlorophyll percentage (%) at mature stage	Leaf Area (cm^2) at 85 DAT	Days to flower bud initiation after transplanting	Number of flower $plant^{-1}$
F_0	49.5 c	78.0 b	49.5 c	47.8 c
F_1	57.1 a	92.2 a	57.1 a	68.7 a
F_2	53.9 b	95.9 a	53.9 b	57.2 b
CV (%)	**5.3**	**11.8**	**6.7**	**7.5**
LSD (0.05)	**1.8**	**6.7**	**2.1**	**2.8**

[X] F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter

(s) differ significantly as per 0.05 level of probability.

Table 6. Combined effect of germplasm and foliar fertilizers on chilli germplasm of growth related attributes [Y]

Treatments[X]	Chlorophyll percentage (%) at mature stage	Leaf Area (cm^2) at 85 DAT	Days to flower bud initiation after transplanting	Number of flower $plant^{-1}$
V_1F_0	50.1 ghi	79.9 defg	47.0 fgh	51.8 gh
V_1F_1	58.9 abc	93.7 cd	55.3 bc	83.0 b
V_1F_2	55.3 bcde	94.9 c	52.5 cde	59.0 f
V_2F_0	52.7 efghi	73.9 efg	46.0 fgh	68.3 cd
V_2F_1	60.9 a	86.8 cde	53.8 cd	90.0 a
V_2F_2	57.2 abcd	92.9 cd	47.8 efg	84.8 ab
V_3F_0	50.2 ghi	49.7 h	44.0 gh	52.5 gh
V_3F_1	59.3 ab	68.0 g	49.0 def	73.8 c
V_3F_2	53.6 defgh	69.5 g	46.0 fgh	62.0 ef
V_4F_0	48.7 ij	69.7 fg	35.5 j	47.3 h
V_4F_1	54.9 def	84.5 cdef	42.8 hi	65.8 de
V_4F_2	53.7 defg	89.4 cd	39.0 ij	56.5 fg
V_5F_0	45.7 j	116.7 b	59.3 ab	19.3 j
V_5F_1	51.2 fghi	128.0 ab	64.0 a	30.8 i
V_5F_2	49.7 hij	132.6 a	60.0 ab	23.8 j
CV (%)	**5.3**	**11.8**	**6.7**	**7.5**
LSD (0.05)	**4.0**	**14.9**	**4.8**	**6.2**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.9 Vitamin C content in green fruit (mg/100g)

Significant differences were observed among the local chilli germplasms in respect of vitamin C content (Appendix V). The ascorbic acid content of the green fruits of five chilli germplasms ranged from 76.4 mg/100 g fruit to 57.9 mg/100 g fruit. The green fruits of V_1 (Akashi) contained the higher amount of ascorbic acid (76.4 mg/100 g fruit) and the lower (57.9 mg/100 g fruit) was recorded in V_3 (deshi kacha morich) (Table 7). The ascorbic acid and vitamin C, besides nutritional potential, contain antioxidant properties and it is present in high concentrations in several types of peppers. The stability and accumulation of Vit-C in fruits of Capsicum was affected by maturation and storage conditions besides genetic diversity (Howard *et al.*, 2000; Jimenez *et al.*, 2003). Four chilli lines also studied and evaluated the Vitamin C content which was ranged from 65.6 mg /100gm fruit to 80.5 mg /100gm fruit (Mehraj *et al.*, 2014). Similar result was obtained by Purseglove (1968) and Bajaj *et al.* (1980).

Two different foliar application treatments adopted in the present study showed significant variation in relation to vitamin C content (Appendix V). Vitamin C content of the green fruits ranged from 75.3 mg/100 g fruit to 58.8 mg/100 g fruit. The maximum vitamin C was found in F_1 (calsol) treatment. The minimum vitamin C content (58.8 mg/100 g fruit) was obtained from F_0 (control) treatment (Table 8). Ejaz *et al.* (2011) found that vitamin C content was enhanced by combined efficacy of macro-nutrients and micro-nutrients as foliar application in tomato. Application of zinc and boron on tomato increase vitamin C content, it was (32.6 mg / 100 g fruit) (Shnain *et al.*, 2014). It is reported that application of micronutrients like Zn, Cu, Fe and Mo are essential for increase in ascorbic acid content in tomato fruits (Gupta and Gupta, 2004).

Effects of foliar application treatments on five chilli germplasms for vitamin C content showed significant variation (Table 9). Vitamin C content of the green fruits ranged from 83.4 mg/100 g fruit to 50.1 mg/100 g fruit. Vitamin C content was the highest (83.4 mg/100 g fruit) in Akashi with F_1(Calsol) treatment and the lowest (50.1 mg/100 g fruit) was in Deshi kacha morich with F_0 (control) treatment (Table 7).

4.10 Vitamin C content in dry fruit (mg/100g)

Significant variations were found between the germplasms in respect of ascorbic acid content of dry fruits (Appendix V). Higher quantity of ascorbic acid (42.6 mg/100 g fruit) was measured in germplasm (V_1) Akashi, while the lower (28.3 mg/100 g) ascorbic acid was found in germplasm (V_3) Deshi kacha morich (Table 7). Similar result was observed in dry chilli composition by Leung *et al.* (1972). In chilli germplasm nutritional composition varies from germplasm to germplasm (Kaur *et al.* 1980) and also location to location (Raina and Teotia, 1985).

Variations among the different foliar application treatments in relation to vitamin C content were statistically significant (Appendix V). Vitamin C content of the dry fruits ranged from (39.5 to 29.8 mg/100 g).The Maximum vitamin C content (39.5 mg/100 g fruit) was found in F_1 treatment, while the minimum (29.8 mg/100 g fruit) was found in F_0 treatment (Table 8).

Chilli germplasm combination with liquid fertilizers significantly effect on quality attributes of fruit (Appendix V). Vitamin C content of the dry fruits ranged from 49.1 to 24.4 mg/100 g. The highest vitamin C (49.1 mg/100 g fruit) was recorded from V_1 (Akashi) with F_1 (Calsol). On the other hand, the lowest (24.4 mg/100 g fruit) was found in germplasm V_3 (Deshi kacha morich) with F_0 (Control) combination followed by (25.7 mg/100 g fruit) treated with V_2 in the same treatment combination (V_2F_0) (Table 9).

4.11 Percentage of protein in green fruit

Protein content showed significant inequality among the germplasm variation (Appendix V). Protein content in fruit ranged from 4.2 to 3.0 %. The highest protein content (4.2 %) was recorded from V_5 (Dongfou) and the lowest protein contents (3.0%) was recorded from V_2 (Kajoli) (Table 7). This might be due to the genetic variation in term of protein synthesis among the germplasms. Purseglove (1968) found that chilli fruits contain 3 percent protein. Similar result was also observed by Srivestava *et al.* (1994) and Leung *et al.* (1972).

Application of liquid fertilizers had significant effect on fruit quality attributes of chilli germplasm(Appendix V and Table 8). Protein content exerted significant inequality among the different foliar application treatments shown in table 8. The result revealed that treatment F_0 (Calsol) scored the highest protein contents (3.9%) in chilli fruits where as the lowest one (2.9%) was received from control (Table 8). Zinc is essential micronutrients for protein production in plants. Zinc is the main composition of ribosome and is essential for their development. Different studies conducted by Pandey *et al*. (2006); Outten *et al*. (2001) and Marschner (1995) showed that Amino acids accumulated in plant tissues and protein synthesis were declined by zinc deficit. Khalid and Shedeed (2015) also reported that the positive effects of these treatments (NPK, foliar nutrition and their interactions) may be due to the important physiological role of N. N plays an important role in synthesis of the plant constituents through the action of different enzymes activity and protein synthesis. This foliar treatment increased protein content in *Nigella sativa L.*

Significant variation was obtained in protein content due to different foliar liquid fertilizers application on germplasm (Appendix V and Table 9). The result showed that the highest protein content (5.1%) was recorded from the combination V_5F_1 (Dongfou x Calsol). The lowest protein contents (2.5%) were gained from the combination V_2F_0 (Kajoli x Control) (Table 9).

Table 7. Fruits quality related attributes of different local chilli germplasm [Y]

Treatments[X]	Vitamin C content in green fruit (mg/100g)	Vitamin C content in dry fruit (mg/100g)	Percentage (%) of protein in green fruit
V_1	76.4 a	42.6 a	3.5 b
V_2	61.8 c	34.3 c	3.0 d
V_3	57.9 d	28.3 d	3.4 bc
V_4	69.4 b	34.7 c	3.4 c
V_5	68.5 b	36.3 b	4.2 a
CV (%)	**1.64**	**3.96**	**4.15**
LSD (0.05)	**0.90**	**1.15**	**0.12**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 8. Effect of liquid fertilizers on fruits quality related attributes of chilli germplasm[Y]

Treatments[X]	Vitamin C content in green fruit (mg/100g)	Vitamin C content in dry fruit (mg/100g)	Percentage % of protein in green fruit (100g)
F_0	58.8 c	29.8 c	2.9 c
F_1	75.3 a	39.5 a	3.9 a
F_2	66.3 b	36.4 b	3.6 b
CV (%)	**0.7**	**0.9**	**0.1**
LSD (0.05)	**1.7**	**4.0**	**4.1**

[X] F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 9. Combined effect of foliar fertilizers and chilli germplasm related attributes of fruits quality of chilli [Y]

Treatments[X]	Vitamin C contain in green fruits (mg/100g)	Vitamin C content in dry fruit (mg/100g)	Percentage (%) of protein in green fruit (100g)
V_1F_0	67.3 e	35.3 e	3.1 gh
V_1F_1	83.4 a	49.1 a	3.8 d
V_1F_2	78.6 b	43.2 c	3.5 f
V_2F_0	50.8 i	25.7 hi	2.5 j
V_2F_1	72.8 d	46.4 b	3.2 gh
V_2F_2	61.9 g	30.9 g	3.3 g
V_3F_0	50.1 i	24.4 i	3.1 h
V_3F_1	67.7 e	33.0 ef	4.0 c
V_3F_2	55.8 h	26.6 h	3.2 gh
V_4F_0	65.4 f	33.1 f	2.8 i
V_4F_1	75.3 c	33.6 ef	3.6 ef
V_4F_2	67.4 e	37.5 d	3.8 de
V_5F_0	60.4 g	30.3 g	3.2 gh
V_5F_1	77.2 b	34.4 ef	5.0 a
V_5F_2	67.6 e	44.1 c	4.3 b
LSD (0.05)	**1.7**	**2.0**	**0.2**
CV (%)	**1.6**	**4.0**	**4.2**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.12 Weight of 50 Fresh fruit

Significant variation was found on fresh weight of fifty fruits with different germplasms of chilli *viz.* V_1 (Akashi), V_2 (Kajoli), V_3 (Deshi kacha morich), V_4 (Bogra morich), V_5 (Dongfou) at mature ripening stage (Appendix VI and Table 10). (Dongfou) gave maximum fresh weight of 50 fruits (183.9 g) while minimum (40.9 g) fresh weight of fifty fruits was obtained from V_2 (Kajoli) (Table 10). The performance of four chilli lines was studied by Mehraj *et al.* (2014). Who found that fresh weight of 50 fruits varied from lines to lines and results of that study supports the findings of the current experiment. Similar result was also obtained by Ukkund *et al.* (2007).

Weight of fifty fresh fruits varied significantly due to application of different foliar fertilizer (Appendix VI and Table 11).Maximum fresh weight of 50 chilli fruit was found in F_1 (Calsol; 81.3 g) treatment whereas lowest in F_0 (Control; 64.6 g) (Table 11). Patil and Biradar (2001) found significant fruit weight of chillies by applying foliar fertilizer “Polyfeed”.

Chilli germplasm in combination with foliar fertilizer significantly influenced the fresh weight of chilli fifty fruits (Appendix VI). Maximum fruits weight was gained from V_5F_1 (Dongfou x Calsol ; 202.0 g) whereas minimum was offered by V_2F_0 (Kajoli x Control; 31.75 g) (Table 12). **M**aximum fresh fruit weight was obtained through foliar application of macro and micro nutrients (HiGrow) in chilli (Baloch *et al.*, 2008).

4.13 weight of 50 dry fruits

Dry weight of 50-fruits was significantly influenced by local chilli germplasms (Appendix VI). Highest dry weight was recorded from V_5 (Dongfou; 19.4 g) while lowest dry weight of fifty-fruits was scored from V_2 (Kajoli; 10.3 g) (Table 10). Dry weight of fruits varied significantly among the cultivars (Chowdhury *et al.,* 2015). The performance of four chilli lines was studied by

Mehraj *et al.* (2014).Who found that dry weight of 50 fruits varied from lines to lines and results of that study supports the findings of the current experiment.

Weight of fifty dry fruits varied significantly due to application of foliar fertilizers compost of macro and micro nutrient solution (Appendix VI). Highest dry weight of chilli was found in foliar treatment by F_0 (Calsol; 15.70 g) whereas, lowest in F_0 (Control; 11.24 g) (Table 11). Among the micro nutrients, only application of boron and mixture of micronutrients enhanced the fruit weight while other micro-nutrients did not show any positive effect. The increase in fruit weight of okra fruits might be due to better mineral utilization of plants accompanied with enhancement of photosynthesis, other metabolic activity and greater diversion of food material to fruits. Bajpai *et al.* (2001) reported that fruit size and weight was increased by application of micronutrients. Similar result was also found by Alkaff and Hassan (2003) in okra.

Dry weight of fifty fruits was statistically significantly influenced by the combination of local chilli germplasm and foliar liquid fertilizers (Appendix VI). The highest weight of fifty dry fruits (V_5F_1; 21.42 g) in Dongfou with Calsol treatment and lowest (V_2F_0; 9.025) Kajoli with control treatment (Table 12). Application of Zinc and Boron increased dry weight of chilli (*Capsium annuum* L.) fruits (Shil *et al.* 2013).

4.14 Fruit diameter

Significant differences were observed among the chilli germplasm in respect of fruit diameter (Appendix VI). Fruit diameter of the five chilli germplasms ranged from 9.9 mm to 7.8 mm. The mature fruits of V_5 (Dongfou) showed maximum fruit diameter (9.9 mm), which was identical with V_1 (Akashi; 9.7 mm) and minimum 7.8 mm was recorded in V_4 (Bogur morich), followed by

V_2 (Kajoli; 7.9 mm) (Fig. 10). Similar findings were also obtained by Gogoi *et al.* (2002), Manju *et al.* (2002) and Smitha *et al.* (2006).

Two different foliar application treatments adopted in the present study showed significant variation in relation to fruit diameter (Appendix VI). Fruit diameter of the mature fruits ranged from 9.9 mm to 7.6 mm. The maximum fruit diameter (9.9 mm) was found in calsol (F_1) treatment. The minimum fruit diameter (7.6 mm) was obtained from control (F_0) treatment (Table 11). Fruit diameter was increased by foliar application of (nitrogen 5.5 g/100 mL + Boron 5 g/100 mL + Zinc 5 g/100 mL) combined fertilizer in tomato plant (Ali *et al.* 2013). Naruka *et al.* (2000) also found that the effect of foliar application of zinc and molybdenum through foliar spray increased fruit diameter. Again according to Ali *et al.* (2014), foliar application of Zn + Cu + Fe + Mn + B micro nutrient enhance fruit diameter of peach.

Chilli germplasm in combination with foliar fertilizers significantly influenced fruit diameter (Appendix VI). Fruit diameter of mature fruits ranged from 11.3 mm to 6.9 mm. Fruit diameter was found highest in (V_5F_1; 11.3 mm) which were also statistically identical with V_5F_2 (10.4 mm) and V_1F_1 (10.8 mm).The lowest fruit diameter (V_4F_0; 6.900 mm) was found in Bogur morich with F_0 (Control) treatment, which were statistically similar with V_3F_0 (7.8 mm), V_4F_2 (7.7 mm), V_2F_0 (7.1 mm) (Table 12).

4.15 Fruit length

Significant variation was recorded for fruit length among chilli germplasms (Appendix).Results indicate that the longest fruit length (93.7 mm) was recorded from V_5 (Dongfou) while V_2 (Kajoli) was shortest (58.3 mm), followed by (V_1; 60.8 mm) (Appendix VI). Fruit length show significant variation with different macro and micro nutrient solution spray (Table 10). Hosmani (1982) suggested that in case of chilli fruits length is having market value because normally medium to long fruit are preferred by customers. But extra large fruit is undesirable because it is usually associated with lower productivity irregular fruit shape and poor quality by Pochard (1966). Smith *et al.,* (2006) observed significant differences among the chilli genotypes in respect of fruit length.

Two different foliar application treatments adopted in the present study showed significant variation in relation to fruit length (Appendix VI). Highest fruit length was found in F_1 (Calsol; 76.18 mm) treatment and the shortest in F_0 (Control; 60.81 mm) treatment (Table 11). A foliar fertilizer "Fetrilon-Combi" was applied in chillies and found considerable improvement in fruit development and crop yield as compared to those supplied only with straight chemical fertilizers (Anonymous, 2007). Natesh *et al.* (2005) also observed that fruit length was increased by foliar spray of micronutrients at flowering stage. Length of fruit was significantly increased by zinc and boron (Wojcik and Wojcik, 2003) application by improving cell size or cell number (Khayyat *et al.,* 2007). Similar result was also obtained by Yadav *et al.* (2001)

Application of fertilizer in combination with chilli germplams significantly influenced fruit length ((Appendix VI)). Maximum fruit length was found from combination (V_5F_1) (99.6 mm) of Dongfou with calsol treatment, followed by combination (V_5F_2) (96.8 mm) Dongfou with waxul treatment. Minimum fruit length was obtained from combination (V_2F_0) (49.4 mm), followed by combination (V_1F_0) (54.5 mm) and (V_3F_0) (54.9 mm) (Table 12). Baloch *et al.* (2008) found similarity through foliar application of macro and micro nutrients (HiGrow) in chilli resulted significantly longer fruits in green chilli.

4.16 Single fruit fresh weight

Individual fruit fresh weight was documented statistical significance among different chilli germplasms like as V_1 (Akashi), V_2 (Kajoli), V_3 (Deshi kacha morich), V_4 (Bogra morich), V_5 (Dongfou) (Appendix VI). Highest individual fruit weight (3.9 g) was obtained from V_5 (Dongfou); whereas the lowest (1.4 g) from V_2 (Kajoli) (Table 10). Obidiebube *et al.* (2012) also found variation in the fresh weight of single fruit among the cultivars of pepper.

Single fruit fresh weight was significantly varied with different liquid fertilizer treatments *viz.* F_0 (Control), F_1 (Calsol) and F_2 (Wuxal) (Appendix VI). Maximum single fruit weight (2.6 gm) was found from F_1 (calsol); which was statistically similar with F_2 (Wuxal; 2.5 gm). On the other hand minimum (1.9 gm) was found in F_0 (Control) (Table 11). Wojcik and Wojcik, (2003) found that zinc and boron improves fruit growth by synthesizing tryptophan and auxin. Sindhu *et al.* (1999) also reported that foliar application of B and Zn increased weight of grape. Boron plays key role on accumulation of photosynthates that has correlation with fruit weight (Shukha, 2011).

Combined effect of different treatments *viz.* F_0 (Control), F_1 (Calsol) and F_2 (Wuxal) on chilli germplasm *viz.* V_1 (Akashi), V_2 (Kajoli), V_3 (Deshi kacha morich), V_4 (Bogra morich), V_5 (Dongfou) in terms of individual fruit weight also exposed significant variation (Appendix VI). Highest result (4.3 g) reported in V_5F_1 and V_5F_2 was found as non significant variation in combination. The lowest single fruit fresh weight (1.1 g) was recorded from V_2F_0 (Table 12).

Table 10. Fruit attributes as influenced by different chilli germplasm[Y]

Treatments[X]	Weight of 50 fresh fruit (g)	Weight of 50 dry fruit (g)	Fruit diameter (mm)	Fruit length (mm)	Single fruit fresh weight (g)
V_1	47.2 c	12.8 b	9.7 a	60.8 d	2.4 b
V_2	40.9 e	10.3 d	7.9 c	58.3 d	1.4 d
V_3	44.7 d	11.7 c	8.8 b	65.9 c	2.0 c
V_4	49.5 b	13.6 b	7.8 c	70.6 b	2.1 c
V_5	183.9 a	19.4 a	9.9 a	93.7 a	3.9 a
LSD (0.05)	**2.1**	**2.1**	**0.5**	**3.3**	**0.2**
CV (%)	**3.5**	**8.1**	**7.3**	**5.7**	**9.6**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 11. Effect of liquid fertilizers on fruits related attributes of chilli[Y]

Treatments[X]	Weight of 50 fresh fruit (g)	Weight of 50 dry fruit (g)	Fruit diameter (mm)	Fruit length (mm)	Single fruit fresh weight (gm)
F_0	64.6 c	11.2 c	7.6 c	60.8 c	1.9 b
F_1	81.3 a	15.7 a	9.9 a	76.2 a	2.6 a
F_2	73.8 b	13.7 b	8.9 b	72.7 b	2.5 a
LSD (0.05)	**1.6**	**0.7**	**0.4**	**2.5**	**0.1**
CV (%)	**3.5**	**8.1**	**7.26**	**5.7**	**9.6**

[X] F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 12. Combined effect of chilli gremplasm and of foliar fertilizers on fruits related attributes chilli [Y]

Treatments[X]	Weight of 50 fresh fruit (g)	Weight of 50 dry fruit (g)	Fruit diameter (mm)	Fruit length (mm)	Single fruit fresh weight (gm)
V_1F_0	43.0 hi	10.2 ghi	8.5 cd	54.5 h	2.1 e
V_1F_1	50.0 ef	15.5 c	10.8 ab	65.3 ef	2.6 c
V_1F_2	48.5 efg	12.8 de	9.9 b	62.6 f	2.4 cde
V_2F_0	31.8 j	9.0 i	7.1 ef	49.4 h	1.1 g
V_2F_1	51.0 e	11.5 efg	8.9 c	64.2 ef	1.4 f
V_2F_2	40.0 i	10.3 ghi	7.8 de	61.4 f	1.6 f
V_3F_0	41.0 i	9.4 hi	7.8 def	54.9 gh	1.6 f
V_3F_1	47.0 fg	13.7 d	9.9 b	74.2 cd	2.1 e
V_3F_2	46.0 gh	12.1 def	8.8 c	68.7 de	2.3 cde
V_4F_0	42.0 i	10.8 fgh	6.9 f	60.4 fg	1.6 f
V_4F_1	56.5 d	16.5 c	8.6 cd	77.6 c	2.5 cd
V_4F_2	50.0 ef	13.5 d	7.7 def	73.8 d	2.2 de
V_5F_0	165.3 c	16.8 c	8.0 cde	84.9 b	3.2 b
V_5F_1	202.0 a	21.4 a	11.3 a	99.6 a	4.3 a
V_5F_2	184.4 b	19.9 b	10.4 ab	96.8 a	4.2 a
CV (%)	**3.5**	**8.0**	**7.3**	**5.7**	**9.6**
LSD (0.05)	**3.6**	**1.6**	**1.0**	**5.7**	**0.3**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Cntrol ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.17 Fruits plant^{-1}

Number of fruit plant^{-1} varied significantly for germplasm variation (Appendix VII). The result indicates that the highest number of fruits (268.3 plant^{-1}) was obtained from the germplasm V_2 (Kajoli). Second highest (242.7) from germplasm V_4 (Deshi kacha morich) which was statistically similar with germplasm V_1 (Akashi) producing (238.5) number of fruit germplasm V_5 (Dongfou) attained the lowest (61.42) number of fruits plant^{-1} (Table 13). Obidiebube *et al.* (2012) found similar result i.e. significant variation from one cultivar to another in number of fruit of chilli. Sreelathakumary *et al.* (2004) observed higher phenotypic and genotypic co-efficient of variation for fruits plant^{-1}.

There was a marked difference among the different foliar fertilizers treatment (Appendix VII). Foliar spray of calsol treatment produced significantly highest number of fruit plant^{-1} (214.8). Significantly lowest number of fruit plant^{-1} (139.1) achieved by the control treatment (Table 14). Similar results found by Malawadi (2003) by treating the chilli seedlings with micronutrients fertilizer “Polyfeed” and reported significant effect on fruit number and fruit weight of chilies. Jiskani (2005) also found that foliar application of zinc 3.0 ppm, copper 1.0 ppm and boron 0.5 ppm produced the highest number of fruits per plant with increased fruit weight and more total yield per plant. The findings of Naruka *et al.,* (2000), Nehra *et al.* (2001) and Sanwal *et al.* (2007) were also similar with the results. Foliar application of balanced nutrition Zn (6%), B (5%), N (2%) increased number of fruit in tomato plant (Ejaz *et al.*, 2011).

Effect of different macro and micro nutrient solution on chilli germplasm played an important role for promoting the number of fruit plant^{-1}. Number of fruit plant^{-1} exposed significant inequality due to different germplasm and foliar treatment combinations (Appendix VII). The highest number of fruit (327.0) was recorded from the combination V_2F_1 (Kajoli with treatment Calsol). The lowest number of fruit (1.7) plant^{-1} was recorded from combination V_2F_0 (kajoli with control treatment). Treatment combinations V_3F_1 (303.3), V_3F_2 (294.5) and V_4F_1 (294.8) provide the second highest number of fruit plant^{-1} (Table 15). Datir *et al.* (2012) found similar results from application of amino acid chelated micronutrients in chilli plant that increased number of fruits. An experiment was conducted by Hatwar *et al.* (2003) to study the effect of foliar application of micronutrients along with the recommended dose of fertilizers on chilli. They reported that the combined spraying of zinc, boron and iron each @ 0.1 per cent along with recommended dose of NPK @150:50:50 caused maximum number of fruits plant^{-1}.

4.18 1000 seed weight

The 1000 seed weight showed significant variation among the different germplasms viz. V_1 (Akashi), V_2 (Kajoli), V_3 (Deshi kacha morich), V_4 (Bogra morich), V_5 (Dongfou) (Appendix VII). Highest 1000 seed weight (3.5 g) was found in Akashi (V_1) whereas non significant variation with V_2 (kajoli).The lowest 1000 seed weight (2.9 g) was obtained from Bogra morich (V_4) whereas non significant variation with deshi kacha morich (V_3) (Table 13). Similar result was obtained by Gogoi *et al.*, (2002).

Application of foliar fertilizer showed significant variation in 1000 seed weight (Appendix VII). Calsol gave the highest 1000 seed weight (3.5 g) followed by Waxul. The lowest 1000 seed weight (2.9 g) was found from control treatment (Table 14). The maximum effect was observed in 100 seed weight by application of micronutrients mixture (Sivaiah *et al.* 2013). Naga *et al.* (2013) also reported that application of micro nutrient mixture in tomato increase (0.352 g) 100 seed weight of tomato compared to the alone control.

The chilli germplasms responded differently to different foliar fertilizer in respect of 1000 seed weight. The highest 1000 seed weight (3.9 g) was found from the interaction effect of dongfou with calsol (V_5F_1) which was statistically similar with V_1F_1, V_1F_2, $V_2F_1$and V_5F_2 treatment combinations (Appendix VII). The lowest seed weight (2.6 g) was found with the combine effect of Bogra morich with control (V_4F_0) combination, which was statistically similar with V_3F_0 (Table 15).

4.19 Yield plant^{-1}

Significant variations in yield plant^{-1} were noticed among the germplasm (Appendix VII). Yield of five chilli germplasms ranged from 568.6 to 171.2 g per plant .The higher (568.6 gm plant^{-1}) was found in V_1 (Akashi). The lower yield (171.2 g plant^{-1}) was noted from the germplasm of V_4 (Bogra morich) (Table 13).Ullah *et al.*, (2011) observed significant variation among chilli genotypes.

The variations among the different foliar application treatments in terms of fruit yield plant^{-1} were significant (Appendix VII). Yield of the fruits plant^{-1} ranged from 466.7 to 229.4 g. The highest yield (466.7 g plant^{-1}) was found in F_1 (Calsol) and the lowest (229.4 gm plant^{-1}) was recorded in F_0 (Control) (Table 14). Similar results were found by Palaniappan *et al.*, (1999) and Nehra *et al.* (2001). Gupta and Gupta (2004) also reported that application of micronutrients like Zn, Cu, Fe and Mo are essential for increasing in yield and quality of tomato fruits.

Five chilli germplasm combined with foliar fertilizer were significant effect on of yield plant^{-1} (Appendix VII).Yield of the fruits plant^{-1} ranged from 803.9 g to 116.2 g. The highest (803.9 g plant^{-1}) fruits was recorded from combination V_1F_1 (Akashi x Calsol). Whereas the lowest (116.2 g plant^{-1}) was found in untreated the combination V_4F_0 (Bogra morich x Control) (Table 15). Application of N, P, K, Ca, Mg and Fe, B, Zn, Mn and Cu as foliar spray and showed increased growth and yield contributing parameters in chili (Radulovic, 1996). Baloch *et al.* (2008) also found that application of commercial foliar fertilizer 'HiGrow' is composed of various macro and micro nutrients was applied on chilies gave better growth and yield compared to other treatments in chilli.

4.20 Fresh fruit yield

The fresh fruit yield ha^{-1} showed significant variation among the different chilli germplasms (Appendix VII).The germplasm Akashi (V_1) gave the highest fruit yield (18.1 t ha^{-1}).The lowest fresh fruit yield (13.3 t ha^{-1}) was obtained from V_4 (Bogra morich) (Table 13).

Application of foliar fertilizers significantly influenced fresh fruit yield per hectare in foliar macro and micro nutrient spray (Appendix VII). The highest fresh fruit yield was obtained from F_1 (Calsol) treatment (17.6 t ha^{-1}) and the lowest yield (12.8 t ha^{-1}) from F_0 (Control) treatment (Table 14). These results in agreement with the findings of Sharma *et al.* (2000). Weerasinghe *et al.* (2014) also found that growth and yield performances of tomato fruit were influenced through macro and micro nutrient supplementation practices.

Chilli germplasm coupled with foliar fertilizers significant effect on fresh fruit yield of chilli germplasm (Appendix VII). Maximum fresh fruit yield (19.6 t ha^{-1}) was found from V_1F_1 which was statistically similar with V_1F_2 and V_3F_1 treatment combinations. Minimum fresh fruit yield (10.4 t ha^{-1}) was recorded in V_4F_0 treatment combination, respectively (Table 15). Similar result were reported by Jiskani, (2005) who obtained that similar result from the application of micronutrient in combination with NPK in chilli. Lovatt (2005) reported that foliar spray of 1% either Polyfeed or Multi 'K' at 45, 60 and 75 days after planting increased the crop yield by about 10 % over unsprayed controlin chilli.

Table 13. Performance of chilli germplasm related to yield [Y]

Treatments[X]	Fruits plant^{-1}	1000 seed weight (g)	Yield plant^{-1} (g)	Fresh fruit yield (t ha^{-1})
V_1	238.5 b	3.5 a	568.6 a	18.1 a
V_2	268.3 a	3.4 a	371.8 c	15.2 c
V_3	242.7 b	3.1 b	488.4 b	16.9 b
V_4	78.0 c	2.9 b	171.2 e	13.3 d
V_5	61.4 d	3.5 a	228.0 d	14.5 c
CV (%)	**4.2**	**6.8**	**11.9**	**6.3**
LSD (0.05)	**6.1**	**0.2**	**35.8**	**0.8**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra morich ; V_5 , Dongfou.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 14. Effect of liquid fertilizers related to fruits yield [Y]

Treatments[X]	Fruits plant^{-1}	1000 seed weight (g)	Yield plant^{-1} (g)	Fresh fruit yield (t ha^{-1})
F_0	139.1 c	2.9 c	229.4 c	12.8 c
F_1	214.8 a	3.5 a	466.7 a	17.6 a
F_2	179.6 b	3.4 b	400.7 b	16.5 b
CV (%)	**4.2**	**6.8**	**11.9**	**6.3**
LSD (0.05)	**4.8**	**0.2**	**27.7**	**0.6**

[X] F_o , Control ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 15. Combined effect of germplasm and foliar fertilizers related to fruits yield [Y]

Treatments[X]	Fruits $plant^{-1}$	1000 seed weight (g)	Yield $plant^{-1}$(g)	Fresh fruit yield (t ha^{-1})
V_1F_0	139.1 f	3.1 de	324.0 e	15.8 cd
V_1F_1	214.8 d	3.8 a	803.9 a	19.6 a
V_1F_2	179.6 e	3.5 abc	577.8 bc	18.9 a
V_2F_0	201.6 d	3.2 de	220.4 g	11.8 f
V_2F_1	327.0 a	3.6 abc	434.6 d	17.6 b
V_2F_2	235.8 c	3.4 bcd	460.4 d	16.3 bc
V_3F_0	207.3 d	2.7 fg	332.4 e	14.5 de
V_3F_1	303.3 b	3.3 cde	603.7 b	19.0 a
V_3F_2	294.5 b	3.2 de	529.0 c	17.3 b
V_4F_0	207.3 d	2.6 g	116.2 i	10.4 g
V_4F_1	294.8 b	3.2 de	203.7 gh	15.1 cde
V_4F_2	226.0 c	3.1 e	193.5 gh	14.3 e
V_5F_0	72.3 g	3.0 ef	153.7 hi	11.4 fg
V_5F_1	81.8 g	3.9 a	287.6 ef	16.5 bc
V_5F_2	80.0 g	3.6 ab	242.7 fg	15.6 cde
CV (%)	**4.2**	**6.8**	**11.9**	**6.3**
LSD (0.05)	**10.6**	**0.3**	**61.9**	**1.4**

[X] V_1 , Akashi ; V_2 , Kajoli ; V_3 , Deshi kacha morich ; V_4 , Bogra Morich ; V_5 , Dongfou ; F_o , Control ; F_1 , Calsol ; F_2 , Waxul.

[Y] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSION

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5.1 Summary

The experiment was conducted on chilli (*Capsicum frutescens*) germplasm at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2013 to July 2014. The main objective of this study was to evaluate morpho-physiological characters, yield and quality of local chilli germplasm and to examine the influence of commercially available liquid fertilizers on local chilli germplasm. The experiment consist of two factors (chilli germplasm and liquid fertilizers).There were five local chilli germplasm (V_1 = Akashi, V_2 = Kajoli, V_3 = Deshi kacha morich, V_4 = Bogra morich, V_5 = Dongfou) and three levels of locally available common liquid fertilizers (F_0 = Control, F_1 = Calsol, F_2 = Wuxal) which in combination made fifteen treatment combinations. The experiment was laid out in factorial Randomized Complete Block Design with four replications (RCBD).

Collected data were statistically analyzed for the evaluation of treatments for the detection of the best local chilli vatiety, the best liquid fertilizer and the best amalgamation. Summary of the results and conclusion have been described in this chapter.

Among the germplasms, V_2 (Kajoli) was the tallest plant (59.5 cm) and V_4 (Bogra morich) was the smallest plant (50.7 cm) at mature stage. Calsol and control treatment gave the tallest (59.5 cm) and smallest (57.0 cm) plant, respectively at mature stage. The combination V_2F_1 offered the tallest (65.7 cm) plant and V_3F_0 treatment combination produce the smallest (48.9 cm) plant at mature stage.

Maximum (33.1) number of branches plant^{-1} was recorded from V_1 whereas, minimum (18.6) branches plant^{-1}from V_5. Among foliar fertilizers maximum branches plant^{-1} was obtained from F_1 (33.0) and minimum from F_0 (23.8). In case of interaction between local germplasm and liquid fertilizers the combination V_1F_1 produced the height number of branches plant^{-1}(93.0) and V_3F_0 gave the lowest.

Monitoring leaf number among germplasms, maximum leaf number (84.1 plant^{-1}) was found in V_2 whereas minimum from V_5 (40.4 plant^{-1}) at mature stage. In case of foliar fertilizers, calsol provided maximum leaf number (78.4 plant^{-1}) whereas minimum from control (67.2 plant^{-1}) at mature stage. In amalgamation, V_2F_1 provided maximum leaf (90.0 plant^{-1}) while minimum from V_5F_0 (35.50 plant^{-1}) at mature stage.

In chilli germplasms the highest chlorophyll (SPADE values) and flowers plant^{-1}were found from germplasm V_2 (56.9%) and (81.0), whereas the lowest found from germplasm V_5 (48.9%) and (24.6). Foliar fertilizers F_1 (Calsol) provide maximum chlorophyll content (57.1%) and flowers plant^{-1} (68.7) minimum from untreated F_0 (49.5%) and (47.8). The highest chlorophyll content was recorded from V_2F_1 (60.9%) and (90), lowest provided by combination V_5F_0 (45.7%) and (19.3).

Maximum leaf area plant^{-1} was found from V_5 (125.8 cm^2) and minimum from V_3 (39.1). The germplasm V5 took maximum days (61.1) to reach flower bud initiation stage after transplanting and V_3 took minimum days for flower bud initiation.

Application of waxul gave the maximum leaf area plant^{-1} (95.9 cm^2) at 85 days after transplanting (DAT) which was identical with calsol (92.2 cm^2) and the control gave the minimum (78.0 cm^2). The combination V_5F_2 and V_5F_1 produced the maximum leaf area plant^{-1} (132.6 cm^2 and 128.0 cm^2). Delayed flower bud initiation was found in V_3F_2, V_5F_1 and V_3F_0 and earlier flower bud was noticed in V_1F_0 combination.

Maximum vitamin C content in green chilli (76.4 mg/100g fruit) and dry chilli (42.6 mg/100g fruit) were found in V_1 (Akashi) whereas its minimum value in V_3 (Deshi kacha morich) (57.89 mg/100 g and 28.26 mg/100 g). The another quality character protein content was found maximum from V_5 (Dongfou) (4.2%) and minimum from V_2 (kajoli) (3.0%) at mature stage.

Maximum vitamin C content was obtained from calsol in green chilli fruits (75.28 mg/100g fruit) and dry chilli (39.47 mg/100g fruit), protein content (3.9%) whereas minimum from F_0 (control) untreated plant (58.80 mg/100 g), (29.77 mg/100 g) and (2.9%).

Treatment combination V_1F_1 offered maximum vitamin C in green and dry chilli and V_3F_0 treatment combination presented minimum. For protein content V_5F_1 the highest and the lowest from V_2F_0.

Regarding chilli germplasms, maximum amount of 50 fresh fruit and 50 dry fruit weight (183.9 g and 19.4 g), highest single fruit weight (3.9 g), maximum length (93.7 mm) and diameter (9.85 mm) were recorded from V_5 (Dongfou) as lesser amount of fresh weight of 50 fruit and dry weight of 50 fruit (40.9 g and 10.3 g), lowest single fruit weight (1.4 g), minimum length (58.3 mm) and diameter (7.9 mm) were got from V_2 (Kajoli).

Liquid fertilizers application in leaves highest fresh weight of 50 fruit and dry weight of fruit (81.3 g and 15.7 g), single fruit weight (2.6 g), length (76.2 mm) and diameter (9.9 mm) were achieved from treatment F_1 (calsol) as minimum amount of 50 fresh fruit and dry fruit weight (64.9 g and 11.2 g), single fruit weight (1.9 g), length (60.8 mm) and diameter (7.6 mm) were got from F_0 (control).

In case of combination, V_5F_1 gave the topmost results in terms of fresh weight of 50 fruit and dry weight f 50 fruit (202.0 g and 21.4 g), single fruit weight (4.3 g), length (99.6 mm) and diameter (11.3 mm) whereas lowest results were acquired from V_2F_0 for 50 fresh fruit and 50 dry fruit weight (31.8 g and 19.0 g), single fruit weight (1.1 g), length (49.4 mm) and diameter (6.9 mm).

The highest number of fruit $pant^{-1}$ was obtained from V_2 (268.3) and 1000 seed weight (3.5 g), yield $pant^{-1}$ (568.6 g), fresh yield (18.1 t ha^{-1}) as found maximum from V_1 whereas the lowest number of fruit $pant^{-1}$ from V_5 (61.4) and 1000 seed weight (2.9 g), yield $pant^{-1}$ (171.2 g), fresh yield (13.3 t ha^{-1}) was found from V_4.

Among foliar fertilizers maximum number of fruit $pant^{-1}$ (214.8), 1000 seed weight (3.5 g), yield $pant^{-1}$ (466.7 g), fresh yield (17.6 t ha^{-1}) resulted from F_1 whereas, minimum number of fruit $pant^{-1}$ (139.1), 1000 seed weight (2.9 g), yield $pant^{-1}$ (229.4 g), fresh yield (12.8 t ha^{-1}) were found from F_0.

Maximum number of fruit $pant^{-1}$ was found from V_2F_1 (327.0) and 1000 seed weight (3.8 g), yield $pant^{-1}$ (803.9 g), fresh yield (19.6 t ha^{-1}) were found from V_1F_1 whereas the lowest number of fruit $pant^{-1}$ from V_5F_0 (72.3) and 1000 seed weight (2.6 g), yield $pant^{-1}$ (116.2 g), fresh yield (10.4 t ha^{-1}) were obtained from V_4F_0.

5.2 Conclusion

Based on the result of the present investigation the following conclusion might be drawn:

1. **1.** The germplasm 'Kajoli' gave the maximum plant height, number of branches plant^{-1}, number of leaf plant^{-1}, flower plant^{-1}, fruit plant^{-1} and chlorophyll content of the leaf. 'Akashi' germplasm produced the second height branches plant^{-1}, leaves plant^{-1}, chlorophyll content which were identical with 'Kajoli'. Fruit diameter and vitamin C content of the fruit were found maximum from 'Akasi'. The germplasm 'Dongfou' performed better in respect fruit characters *viz*. weight of 50 fresh and dry fruits, single fruit fresh weight, fruit length, fruit diameter and protein content.
2. **2.** The growth parameter *viz* plant height, number of branches plant^{-1}, number of leaf plant^{-1}, number of flower plant^{-1} were found maximum from the foliar fertilizer, Calsol. This liquid fertilizer also performed best in respect of fruit characters as well as yield attributes namely, single fruit fresh weight, fruit diameter, fruit length, fruits plant^{1}, 1000 seed weight and vitamin C content.
3. **3.** The germplasm 'Akashi' and the foliar fertilizer 'Calsol' independently as well as in combination produced the highest fresh fruit yield of chilli.

5.3 Recommendations

Based on the findings of the research, the following recommendations are suggested:

1. **1.** The local chilli germplasm 'Akashi' are suitable for commercial production in farmer's field.
2. **2.** Calsol (macro and micro nutrient solution) as foliar fertilizer can be used higher yield and quality fruit production of chilli.

5.4 Suggestions

Further research in the following areas may be carried out:

1. The findings obtained from the present investigation should be confirmed by conducting similar type of experiment in different agro-ecological zones (AEZ) of Bangladesh.
2. It needs to conduct related research work with others local chilli germplasm.
3. Information about foliar fertilizer application needs to be disseminated to the farmer's level and adopted in their field for more production of chilli.

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APPENDICES

APPENDICES

Appendix I. Analysis of variance of the data on plant height at different day after transplanting (DAT) of chilli germplasm

		Mean Square for plant height				
Source of variation	**Degrees of Freedom (df)**	**45 DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**85 DAT**
Factor A	4	26.719*	50.856*	105.75*	70.126*	140.755*
Factor B	2	154.73*	269.5*	376.26*	345.01*	277.356*
AB	8	1.099*	9.151*	14.979*	22.711*	22.095*
Error	42	0.264	0.765	0.749	2.426	1.461

'*' indicates significant at 0.05 level of probability

Appendix II. Analysis of variance of the data on branches number at different day after transplanting (DAT) of chilli germplasm

		Mean Square for branches number				
Source of variation	**Degrees of Freedom (df)**	**45 DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**85 DAT**
Factor A	4	150.892*	226.275*	419.558*	250.858*	395.417*
Factor B	2	71.717*	56.15*	306.163*	72.217*	430.417*
AxB	8	2.842*	3.275*	16.621*	7.633*	28.104*
Error	42	2.251	2.702	10.23	1.663	14.911

'*' indicates significant at 0.05 level of probability

Appendix III. Analysis of variance of the data on leaf number at different day after transplanting (DAT) of chilli germplasm

		Mean Square for leaf number				
Source of variation	**Degrees of Freedom (df)**	**45 DAT**	**55 DAT**	**65 DAT**	**75 DAT**	**85 DAT**
Factor A	4	4277.6*	4555.433*	4429.08*	4159.475*	4161.03*
Factor B	2	422.44*	763.117*	582.05*	434.817*	651.267*
AxB	8	8.873*	21.658*	6.008*	13.150*	18.975*
Error	42	5.487	7.066	7.537	8.446	6.555

'*' indicates significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on Chlorophyll content, Leaf area (cm^2), Days to flower bud initiation after transplanting , number of flowers plant^{-1} of chilli germplasm

		Mean Square for			
Source of variation	**Degrees of Freedom (df)**	**Chlorophyll (%)**	**Leaf area (cm^2)**	**Days to flower bud initiation after transplanting**	**Flowers plant^{-1}**
Factor A	4	110.296*	6423.478*	771.442*	5141.275*
Factor B	2	290.030*	1787.198*	220.200*	2180.617*
AxB	8	4.452*	11.455*	5.117*	83.638*
Error	42	7.901	109.206	11.117	18.604

'*' indicates significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on vitamin C in green fruit (mg/100g), vitamin C in green fruit (mg/100g), protein (%)in green fruit of chilli germplasm

Source of variation	Degrees of Freedom (df)	Mean Square for		
		Vitamin C in green fruit (mg/100g)	Vitamin C in green fruit (mg/100g)	Protein (%)in green fruit (100g)
Factor A	4	618.746*	313.129*	2.197*
Factor B	2	1362.091*	492.121*	5.077*
AxB	8	27.543*	120.774*	0.390*
Error	42	1.202	1.948	0.021

'*' indicates significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on weight of 50 fresh fruits (g), weight of 50 dry fruits (g), fruit diameter (mm), fruit length (mm), single fruit fresh weight (gm) of chilli germplasm

Source of variation	Degrees of Freedom (df)	Mean Square for leaf number				
		Fresh fruit (50) weight (gm)	Dry fruit (50) weight (gm)	Fruit diameter (mm)	Fruit length (mm)	Single fruit fresh weight (gm)
Factor A	4	46045.290*	144.830*	11.664*	2401.535*	10.556*
Factor B	2	1399.098*	99.842*	25.259*	1297.667*	2.793*
AxB	8	158.017*	1.721*	0.584*	10.949*	0.130*
Error	42	6.464	1.197	0.409	15.695	0.051

'*' indicates significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on number of fruits plant^{-1}, 1000 seed weight (g), Yield (g) plant^{-1}, Yield (t ha^{-1}) plot^{-1}of chilli germplasm

		Mean Square for leaf number			
Source of variation	**Degrees of Freedom (df)**	**Number of Fruits plant^{-1}**	**1000 seed weight (gm)**	**Yield (g) plant^{-1}**	**Yield (t ha^{-1})**
Factor A	4	118780.733*	0.788*	339139.317*	140.755 *
Factor B	2	28699.267*	1.811*	300185.066*	277.356*
AxB	8	5418.746*	0.043*	26515.672*	22.095*
Error	42	55.594	0.050	1883.844	1.461

‘*’ indicates significant at 0.05 level of probability