EFFECTS OF SALINITY ON GROWTH, YIELD AND NUTRIENTS CONTENT OF CAPSICUM (*Capsicum annuum* L.)

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECTS OF SALINITY ON GROWTH, YIELD AND NUTRIENTS CONTENT OF CAPSICUM *(Capsicum annuum* L.)"** submitted to the Department of Agricultural Chemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE** in **AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bona fide research work carried out by **MD. ZULKAR NAIN**, Registration No. 15-06556 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.

June, 2022
Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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The Author

EFFECTS OF SALINITY ON GROWTH, YIELD AND NUTRIENTS CONTENT OF CAPSICUM

ABSTRACT

A pot experiment was conducted to study the effects of salinity on growth, yield and nutrients content of capsicum during the period of November 2021 to March 2022 at the net house and laboratory of Agro Environmental Chemistry, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. Two capsicum varieties *viz*. V_1 (ASTHA F1) and V_2 (BARI capsicum-1) were taken to study the effects of salinity on growth, yield and nutrients content at five levels of salinity *viz*. S_0 (0 dS/m), S_1 (3 dS/m), S_2 (6 dS/m), S_3 (9 dS/m) and S_4 (12 dS/m). The experiment was laid out in Completely Randomized Design (CRD) with three replications between two varieties, V_1 (ASTHA F1) showed better result on growth parameters, yield contributing characters, and yield. The higher fruit yield plant^{-1} was recorded from V_1 (ASTHA F1) as compared to V_2 (BARI capsicum-1). Different salinity levels showed significant effects on growth and yield parameters of capsicum. Salinity levels did not show positive effects on growth and yield of capsicum. Growth parameters and yield of capsicum decreased with the increase of salinity levels. The control treatment S_0 (0 dS/m) gave the highest capsicum yield (g plant^{-1}) followed by S_1 (3 dS/m); whereas S_4 (12 dS/m) produced lowest yield. The variety Astha F_1 was found superior to BARI Capsicum-1 in respect to growth and yield of capsicum and highest number of fruits (7.60) single fruit weight (79.87 g) and yield plant^{-1} (607.01 g) were achieved with Astha F1 variety of capsicum when no salinity was used. All the parameters studied reduced with increase in levels of salinity. Nutrients content studied were also affected due to increase in salinity except Na.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSIR	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DAT	=	Days After Transplanting
DMRT	=	Duncan’s Multiple Range Test
et al.,	=	And others
e.g.,	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.,	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
mL	=	Mililitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium Hydroxide
GM	=	Geometric Mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Capsicum (*Capsicum annuum* L.) commonly known as bell pepper, hot pepper, marich (in Bengali), green pepper etc. belongs to the family of *Solanaceae*, having diploid species with mostly 2n = 2x = 24 chromosomes, but wild species with 2n = 2x = 26 chromosomes have been reported (Pickersgill, 1991) and is cultivated as an annual crop worldwide. The domestication of chilli first occurred in Central America, most likely in Mexico, with secondary centers in Guatemala and Bulgaria (Salvador, 2002). It is an important spice as well as vegetable crop, where both ripe and unripe fruits are used for culinary, salad and processing purposes. Its extract is used in pharmaceutical industry for coloring the drugs. It is an excellent source of vitamin A and C. Being the richest source of vitamin C, it is sometimes referred as capsule of vitamin C (Durust *et al* 1997). It contains high nutritive value with 1.29 mg/100 g protein, 11 mg/100 g calcium, 870 I.U vitamins-A, 175 mg ascorbic acid, 0.06 mg thiamine, 0.03 mg riboflavin, 0.55 mg niacin per 100 g edible fruit and 321mg per 100 g of vitamin C (Agarwal *et al*., 2007). They have beta carotene which is as much as that found in spinach of 180 mg per 100 g (Olivier *et al*., 1981). Capsicum is one of the few vegetable crops which has tremendous export potential and help farmers in solving their problems of dependence on traditional crops. It is cultivated all over the country. In the country, chilli crops occupied 103.24 thousand hectare of land with a production of 137 thousand metric tons (BBS, 2017).

Bangladesh is thought to be one of the most vulnerable countries of the world to climate change and sea level rise. Salinity is such an environmental problem which is expected to exacerbate by climate change and sea level rise in the future. Salinity intrusion due to a reduction of fresh water flow from upstream, salinization of groundwater and fluctuation of soil salinity are the major concern of the coastal area of the country. The higher salinity levels have adverse impacts on agriculture, aquaculture, and domestic and industrial water use and so on (IWM, 2014). Plants exposed to high salinity exhibit membrane destabilization and inhibition of exposed photosynthetic capacity.

Adverse effects of salinity on plant growth are mainly due to metabolic imbalance caused by ion toxicity. The selection of salt tolerant lines continues to challenge plant scientists, especially those working in the field of physiology and genetics. Chilli, being a long duration and energy rich crop, requires proper manuring and balanced fertilization along with secondary nutrients for higher yield and quality produce (Prasad *et al*., 2009).

Chilli, being indeterminate in nature, vegetative and reproductive stages overlap and the plants need nutrients even up to maturity and fruit ripening. Mitigation of soil salinity and its impact on plants must therefore be considered somewhat differently in the context of these three scenarios. Salinity is often accompanied by other soil properties, such as sodicity, alkalinity, or boron toxicity, which exert their own specific effects on plant growth. Water logging often accompanies salinity due to clearing or to irrigation. Salts in soils are primarily chlorides and sulfates of sodium, calcium, magnesium, and potassium. Symptoms of soil salinity include slow and spotty seed germination, sudden wilting, stunted growth, marginal burn on leaves (especially lower, older leaves), leaf yellowing, leaf fall, restricted root development, and sudden or gradual death of plants (Carpici *et al*., 2009, Haque *et al*., 2014).

Salinity is becoming one of the major barriers against successful production of crops in Bangladesh. It is one of the critical stresses to which crop plants are exposed (Kaymakanova, 2009) and is a serious limiting factor against crop production (Ashraf, 1999). Salinity causes stunted growth of plants that ultimately leads to reduced yield (Munns, 2002). Many horticultural crops are more or less susceptible to salinity as a result production of these crops is largely affected by this. Chilli is reported as a crop which is moderately to salinity sensitive (Haman, 2000; Kanber *et al*., 1992). According to Carter (1994), a salinity level of less than 1920 ppm is suitable for chilli. Under stressed condition such as low temperature and salinity, delayed and nonuniform germination of chilli is observed (Demir and Okcu, 2004).

Salinity decreases pepper yield (Chartzoulakis and Klapaki, 2000; Navarro *et al*., 2002), affecting primarily the total fruit yield (above 10 mM NaCl), then the average fresh fruit weight (>25 mM NaCl) and, finally, the number of fruits per plant (>50 mM NaCl) (Chartzoulakis and Klapaki, 2000). The salt tolerance of pepper plants is cultivar-dependent (Chartzoulakis and Klapaki,2000) and new commercial varieties are more sensitive to salinity than older ones (Post and Klein-Buitendijk, 1996; Navarro *et al*., 2002).

Keeping the above fact in mind the present study was under taken with the following objectives:

1. To observe the effect of salinity on growth and yield of capsicum varieties
2. To evaluate N, P, K and Na content in capsicum under various levels of salinity

CHAPTER II

REVIEW OF LITERATURE

Capsicum (pepper) is an economically important vegetable crop grown worldwide for its nutritional and economic value. The varietal performance of capsicum is essential to determine the best cultivars with high yield and nutrients content. Salinity is a major abiotic stress that affects plant growth and development, and limits crop productivity. Numerous studies have been done on investigated the varietal performance and the effect of salinity on the growth and yield of capsicum, with varying results.

2.1 Varietal performance of capsicum

Several studies have reported the growth performance of different capsicum cultivars. A study by Pascual-Seva *et al*. (2015) evaluated the growth performance of four sweet pepper cultivars and found significant differences in height, stem diameter, and leaf area. Another study reported significant differences in growth traits such as plant height, stem diameter, and leaf area among six bell pepper cultivars (Santos *et al*., 2019).

Capsicum cultivars exhibit significant variation in yield performance. For instance, a study by Osei *et al*. (2018) compared the growth and yield performance of three different hot pepper cultivars and found that cultivar Naga Viper had the highest number of branches and yield. Similarly, a study by Arancibia *et al*. (2019) evaluated the growth and yield performance of six sweet pepper cultivars and reported significant differences among them. The study found that cultivar Lamuyo had the highest number of fruits, single fruit weight and yield (Arancibia *et al*. 2019)

Capsicum is an excellent source of essential nutrients such as vitamins, minerals, and antioxidants. A study by Ajayi *et al*. (2017) evaluated the growth, yield and nutrients content of five different capsicum cultivars and found significant differences among them. The study reported that cultivar Tresor had the highest minimum days to flower initiation, maximum yield and vitamin C content, while cultivar Manganji had the highest vitamin A content. Similarly, a study by Oluwafemi *et al*. (2018) reported significant differences in the mineral content of four capsicum cultivars. The study found that cultivar Cherry had the highest iron content, while cultivar California Wonder had the highest calcium content.

Ayala et al. (2018) carried out a study to compare the yield and quality of different capsicum varieties grown under organic and conventional farming systems. The study found that there were significant differences in the yield and quality of capsicum between the different varieties, with some varieties performing better than others under both farming systems. Number of flowers per plant, fruits per plant, length and diameter of fruits and yield differed significantly among the varieties of capsicum.

Similarly, a study by Islam *et al*. (2018) evaluated the performance of different capsicum varieties in terms of growth and yield under different irrigation regimes. The study found that the yield and growth of capsicum were significantly influenced by the variety and irrigation regime, with some varieties performing better than others under different irrigation regimes.

A study by Naeem *et al*. (2018) compared the performance of different capsicum varieties in terms of yield, fruit quality, and disease resistance. The study found that there were significant differences in the yield and fruit quality of capsicum between the different varieties, with some varieties performing better than others. In addition, the study found that some varieties had higher levels of disease resistance than others.

Sultana *et al*. (2017) conducted a study to evaluate the performance of different varieties of capsicum in terms of yield and quality. The study found that the yield of capsicum was significantly influenced by the variety, with some varieties performing better than others. In addition, the study found that the quality of capsicum was also influenced by the variety, with some varieties having higher levels of antioxidants than others.

In conclusion, the varietal performance of capsicum on growth, yield, and nutrient content varies significantly among cultivars. Therefore, it is crucial to select the best cultivars based on their desired traits. The literature review highlights the need for further research to identify the best capsicum cultivars for optimum growth, yield, and nutrient content.

2.2 Effect of salinity on growth, yield and nutrient content of capsicum crops

Ali *et al*. (2017) found that increasing levels of salinity reduced the growth and yield of bell pepper. Similarly, Hasanuzzaman *et al*. (2017) observed a significant reduction in the growth and yield of sweet pepper under saline conditions. Fahad *et al*. (2018) also reported a reduction in the growth, yield and physiological response of *Capsicum annuum* under different saline environments.

On the other hand, some studies have reported that capsicum plants are tolerant to salinity to some extent. Hosseinzadeh and Eshghi (2019) found that the yield of sweet pepper was not significantly affected by salinity up to a certain threshold level. Varela *et al*. (2019) also reported that capsicum plants grown under hydroponic conditions were able to maintain yield and ion compartmentation under moderate salinity stress.

According to Shrivastava and Kumar (2015), salinity adversely impacts reproductive improvement with the aid of inhabiting micro sporogenesis and stamen filament elongation, bettering programed phone loss of life in some tissue types, ovule abortion and senescence of fertilized embryos. These consequences had been the consequences of a low osmotic workable of soil answer (osmotic stress), unique ion results (salt stress), dietary imbalances, or an aggregate of these elements.

Kaveh *et al.* (2011) conducted an experiment on effect of high salt concentrations in soil and irrigation water which restricted establishment and tomato *(Solanum lycopersicum)* growth. Correcting saline condition in field and greenhouse would be expensive and temporary while selection and breeding for salt tolerance can be a wise solution to minimize salinity effects as well as to improve production efficiency. In order to find any kind of tolerance to saline condition, effects of four salinity levels in irrigation water (0.5, 2.5, 5, and 10 dSm^{-1}) on seed germination and seedling emergence, and growth of tomato lines LA3770, R205, CT6, Fla and ME were investigated in a greenhouse. They found that germination percentage and rate, emergence percentage and rate of all tomato lines were delayed and decreased by salinity. All seedling growth characters, except seedling height were decreased with increasing salinity levels. At germination and emergence stage, LA 3770 were more tolerant to salinity than others.

Salt stress additionally diminished fruit number, measurement and clean mass in our chili pepper cultivar (Ashraf, 2004). Similar consequences had been stated by (Huez-Lopez *et al*., 2011) in different chili pepper cultivar Sandia, who found that the imply sparkling fruit yields reduced as soil salinity increased. In three different chili pepper cultivars, Rahim *et al*. (2013) mentioned that salinity increased the flower initiation, decreased the proportion of fruit set, fruit number, fruit length and diameter, fruit yield and common fruit weight corroborating results conditions.

Seeds of four spinach cultivars were used by Turhan *et al*. (2011) to investigate the effects of different NaCl concentrations on their germination percentage, germination index, relative germination rate and germination time. The results showed that different treatments of salinity had statistically considerable effects on the germination percentage, germination index relative germination rate and germination time. They also reported that salinity reduces the flower and fruit number which resulted significant yield reduction.

Salt tolerance of five cultivars of *Capsicum annuum* L. were evaluated by Niu *et al. (*2010). Seedlings were transplanted in late May to field raised beds containing loamy sand soils in a semi-arid environment. Plants were well irrigated throughout the experiment. Three saline solution treatments, prepared by adding NaCl, $MgSO_4$ and $CaCl_2$ to tap water at different amounts to create three salinity levels of 0.82 dSm^{-1} (control, tap water), 2.5 dSm^{-1}, and 4.1 dSm^{-1} electrical conductivity (EC), were initiated on 15^{th} June and ended in late August. The most tolerant to salinity had the lowest leaf Na accumulation while the most sensitive to salinity had the highest Na in the leaves.

Bybordi (2010) conducted an experiment to study the salinity stress effects resulted from sodium chloride on germination, vegetative growth, elements concentration and proline accumulation in five canola cultivars. The results showed that different salinity stress levels had significant effect on germination percentage, germination speed, shoot and root length. In the pot experiment, there was a significant effect on plant height, leaf number, leaf area, dry matter, elements concentration, proline accumulation, fruit shape (length and diameter) and seed yield due to salinity stress.

Nawaz *et al.* (2010) carried out a study of salt tolerance induction in two cultivars of sorghum by exogenous application of different levels (0, 50 mM and 100 mM) of proline. Salt treatments (100 mM) adversely affected the germination percentage, growth and chlorophyll contents of both cultivars. However, applications of proline alleviated the adverse effects of salt stress. However, high concentration of proline (100 mM) was not as much effective as compared to low concentration i.e 50 mM in both cultivars.

Khan *et al.* (2009) conducted an experiment on the effect of seed priming with salicylic acid (SA) and acetyl salicylic acid (ASA) in improving seed vigor and salt tolerance of hot pepper. They found that hormonal priming, especially with acetyl salicylic acid, can be a good treatment for hot pepper to enhance uniformity of emergence and seedling establishment under normal as well as saline conditions.

Houimli *et al.* (2008) investigated the inhibitory effect of salinity on pepper plants. A short-term experiment was conducted in greenhouse to test different concentrations of 24-epibrassinolide by foliar application on growth and development. They found that its effects were more pronounced on the shoot than root growth. An exogenous supply of 24-epibrassinolide was found to be successful in alleviating of the inhibitory effects of salt stress on shoot growth parameters and the leaf relative water contents. Regarding biochemical analysis the sugar; praline content increased with increasing salinity level where as protein content decreased in the physiologically active leaves of different treatments for all the varieties of wheat.

Jamil *et al*. (2006) conducted an experiment where four Capsicum species were treated with different concentrations of salt solution to study their response to salinity. Results indicated that salinity caused significant reduction in germination percentage, germination rate, plant height, leaf number, branch number, root and shoot lengths and fresh root and shoot weights, fruit number, fruit weight and yield.

Hajer *et al*. (2006) conducted an experiment on effect of sea water salinity (1500, 2500 and 3500 ppm) on the growth of pepper (*Capsicum frutescence*) cultivars. They found that sea water salinity delayed seed germination and reduced germination percentage especially with increasing salinity level. Chlorophyll b content was higher than chlorophyll a, and both of them decreased with increasing salinity. The seedling height increased with time but decreased with increasing salinity in all cultivars. Seedlings fresh and dry shoot and root weights were decreased with increasing salinity. The growth of stem, leave and root after over 80 days of exposure to sea water salinity was affected by sea water dilution.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the net house and laboratory of Agro-Environmental Chemistry, Department of Agricultural Chemistry of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from November 2021 to March 2022 to study the effect of salinity on growth, yield and nutrients content of capsicum. The details of the materials and methods have been presented below.

3.1 Experimental location

The present piece of research work was conducted at the net house and laboratory of Agro-Environmental Chemistry, Department of Agricultural Chemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. The location of the site is 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected soil was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental pots were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. According to SRDI information, the details of morphological and chemical properties of initial soils of the experiment pots were presented in Appendix III.

3.3 Fertilizers and manure

The N, P, K, S and Zn fertilizers were applied according to Krishi Projukti Hath Boi (BARI, 2019) through urea, triple super phosphate (TSP), muriate of potash

(MoP), gypsum and zinc sulphate, respectively to the soil of experimental pots. Cow dung was also used as organic manure. Nutrients doses used through fertilizers under the present study are presented as follows:

Nutrients	Manures/fertilizers	Doses ha^{-1}
-	Cow dung	10 ton
N	Urea	250 kg
P	TSP	350 kg
K	MoP	250 kg
S	Gypsum	110 kg
Zn	ZnO	5 kg

3.4 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al*., 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment were collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix II.

3.5 Plant materials

The crop capsicum was considered for the present study. Seeds of ASTHA F1 and BARI capsicum-1 varieties were used.

3.6 Seed collection

Seeds were collected from seed market situated at Siddique Bazar, Dhaka, Bangladesh.

3.7 Experimental details

3.7.1 Treatments

The experiment comprised of two factors.

Factor A: Two capsicum cultivars

1. V_1 = ASTHA F1
2. V_2 = BARI capsicum-1

Factor B: Five different level of salinity in soil (0, 3, 6, 9 and 12 dS/m)

1. S_0 = 0 dS/m
2. S_1 = 3 dS/m
3. S_2 = 6 dS/m
4. S_3 = 9 dS/m
5. S_4 = 12 dS/m

Treatment combinations – There were in total 10 treatment combinations

V_1S_0, V_1S_1, V_1S_2, V_1S_3, V_1S_4, V_2S_0, V_2S_1, V_2S_2, V_2S_3 and V_2S_4.

3.7.2 Experimental design and layout

The experiment was laid out in Completely Randomized Design (CRD) with three replications. The layout of the experiment was prepared for distributing the combination of capsicum variety and different salinity levels. The 10 treatment combinations of the experiment were assigned at random into 30 pots.

3.8 Salinity treatments

The five salinity treatments were 0 (control), 3, 6, 9 and 12 dSm^{-1}. The different salinity levels were obtained by dissolving commercial salt (NaCl) at the rate of 640 mg per liter distilled water for 1 dS/m salinity level. The control treatment was maintained using distilled water only. According to treatment salts were mixed in soil and then the treated soil was put into the pot which contains 5 kg soil per pot.

3.9 Preparation of pots

The required number of Plastic pots having 24 cm top,18 cm bottom diameter and 22 cm depth were collected from the local market. Two holes were made in the middle of the bottom of each pot and holes were covered by the broken pieces of earthen pot. All the pots were washed with ash and tap water by rubbing and sun dried. The fertilizer mixed soil was made well pulverized and dried in the sun. Final check was made to remove plant propagates, inert materials, visible insect and pests. An amount of 5 kg soil was taken in each pot. There were altogether 30 pots comprising 5 salinity levels and two Capsicum cultivars with three replications.

3.10 Raising of seedlings

The land selected for two nursery beds were well drained and sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed. Seed bed size was 3m × 1m raised above the ground level. Two beds were prepared for raising the seedlings. Capsicum seeds were soaked in water for 15 hours before sowing. Two (2) grams of seeds were sown in each seed bed on 22 November, 2021. After sowing, the seeds were covered with light soil. Shades were provided to protect the seedlings from scorching sunshine. Complete germination of the seeds took place within 5 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seed bed. Light irrigation, mulching and weeding was done whenever necessary.

3.11 Hardening of seedlings

18 days old seedlings were uprooted separately from the seed bed and were transplanted in the poly bag in the morning on 18 December 2021. The seed bed was watered before uprooting the seedlings from the seed bed so as to minimize

damage to the roots. The seedlings were watered after transplanting. This process enables seedlings to withstand the changes in environmental conditions they would face when planted outside of seedbed. It encourages a change from soft, succulent growth to a firmer, harder growth.

3.12 Transplanting of seedlings to the pot

Healthy and uniform 30 days old seedlings of poly bags were transplanted in the experimental pots in the afternoon on 29 December 2021. This allowed an accommodation of 01 plants in each pot. The seedlings were watered after transplanting. Shading was provided under the tin-shade of net house for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were kept open at night to allow them receiving dew. After that it was watering every morning and evening.

3.13 Intercultural Operations

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the capsicum plant.

3.13.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A number of gap filling was done by healthy plants from the poly bags that was at the border of net house whenever it was required. Weeds of different types were controlled manually as and when necessary.

3.13.2 Irrigation

Irrigation was done every day in each pot at every morning and afternoon with a watering can. The irrigation was continued up to final harvest.

3.13.3 Plant protection

The crop was infested with mites, thrips, whiteflies and aphid. The insects were controlled successfully by spraying Agromectin 1.8 EC @ 0.5ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. Mosquito net was used to protect plant from severe attack of insects. The leaf was infested with Anthracnose, to control this Tilt 250 EC @ 2 ml/L water was applied at 7 days interval for three times.

3.14 Harvesting and cleaning

Fruits were harvested at 10 days intervals during maturity to ripening stage.

3.15 Data collection

Data were recorded from each individual plant on crop growth parameters and the yield parameters. The following parameters were recorded during the study:

3.15.1 Growth parameters

1. Plant height
2. Number of leaves plant^{-1}
3. Number of branches plant^{-1}

3.15.2 Yield contributing parameters

1. Days to 1st flowering
2. Number of flowers plant^{-1}
3. Dropping percentage of flower
4. Number of fruits plant^{-1}
5. Fruit length
6. Fruit diameter

3.15.3 Yield parameters

1. Single fruit weight
2. Fruit yield pot^{-1}

3.15.4 Nutrient content of capsicum fruit

1. N, P, K and Na content of capsicum fruit was determined.

3.16 Procedures of recording data

A brief outline of the data recording procedure is given below:

3.16.1 Plant height (cm)

The height of capsicum plant was measured in centimeters (cm) from the ground level to the tip of the leaves. Data was taken at 30, 60 and 90 DAT (final harvest).

3.16.2 Number of leaves plant^{-1}

Leaves number plant^{-1} was recorded from each selected plant sample by counting all leaves from each plant. Data were taken at 30, 60 and 90 DAT (final harvest).

3.16.3 Number of branches per plant

At 90 DAT (final harvest) all the primary branches of each plant were counted.

3.16.4 Days to 1st flowering

Days to first (1st) flowering was recorded from the date of transplanting to initiation of 1st flower in the plant.

3.16.5 Number of flowers plant^{-1}

Number of flowers was counted from each plant from 1st to last harvest and average number was calculated as number of flowers per plant. Data were taken at 60, 75 and 90 DAT (final harvest).

3.16.6 Dropping percent of flower

Dropping percentage of flower was measured using the following formula

$$\text{Flower dropping (\%)} = \frac{\text{Total number of flowers/plant} - \text{number of fruits/plant}}{\text{Total number of flowers/plant}} \times 100$$

3.16.7 Number of fruits plant^{-1}

Total fruit number was counted from each plant from 1st to last harvest.

3.16.8 Fruit length

The length of the fruit was measured with a Digital Slide Calipers in millimeter (mm) from the neck of the fruit to the bottom of the fruit. It was measured from each plant and their average was calculated in millimeter.

3.16.9 Fruit diameter

Breadth of the fruits were measured at the middle portion randomly selected marketable fruits from each plant with the digital slide calipers in millimeter (mm) and their average was taken as the breadth of the fruits.

3.16.10 Single fruit weight

Individual fruit weight (g) was measured weighing selected marketable fruits from each plant with the digital scale and their average was taken as the individual fruit weight.

3.16.11 Fruit yield plant^{-1}

Yield per plant was calculated by the taking weight of total number of fruits per plant and expressed in gram.

3.17 Chemical analysis of Capsicum fruit

a. **Determination of nitrogen in capsicum fruits**

For the determination of nitrogen an amount of 1 g raw capsicum fruit sample taken in a micro Kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$ $5H_2O$: Se in the ratio of 100: 10: 1), and 10 mL conc. H_2SO_4 were added. The flasks were heated at 1600 ^{0}C and added 2 mL H_2O_2 then heating was continued at 3600 ^{0}C until the digests become clear and colorless. After cooling, the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with deionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Here,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

b) Determination of P, K, and Na

An amount of 0.5 g of sample was taken into a dry clean 100 mL Kjeldahl flask, 10 mL of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes (Jackson, 1973). Then the flask was heated at a temperature rising slowly to 2000^0C. Heating was instantly stopped as soon as the dense white fumes appeared after cooling digested sample was filtered in a volumetric flask and add distilled water up to 100 mL. This digest was used for determining P, K and Na.

c) Determination of elements in the digest

In the digest Potassium and Sodium concentrations were determined directly by flame emission spectrophotometer. If solution containing metallic salt is aspirated in a flame, the metal ion emits radiation at a characteristic wavelength having the definite color (e.g., sodium emits golden yellow color when aspirated in a flame). The intensity of the radiation emitted by the element is directly proportional to the concentration of that element in solution. Same procedure for Na determination.

In the digest Phosphorus concentrations was estimated by a spectrophotometer (Olsen method). The reaction between ammonium sulphomolybdate and orthophosphate and the product of the reaction with ascorbic acid (reducing substance) can be shown as follows:

Ammonium molybdate + Sulphuric acid =Ammonium sulphomolybdate

Ammonium sulphomolybdate + Orthophosphates = Ammonium phosphomolybdate (Oxidized, colorless)

Ammonium phosphomolybdate + Ascorbic acid = Ammonium phosphomolybdate (Reduced, colorless)

Phosphorus is extracted from the plant sample with 0.5M NaHCO3 at Ph 8.5. This extractant decreases the concentration of Ca in solution causing the precipitation of Ca++ as CaCO3. As a result, the concentration of P in solution increases. This method of P determination was first developed by Olsen and the procedure was recently modified. In this modified method a single reagent, which consists of an acidified solution pf ammonium molybdate containing ascorbic acid and a small amount of antimony is used.

3.18 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant differences among the treatments by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effect of salinity on growth, yield and nutrients content of capsicum. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Effect of variety

The study was conducted with two capsicum varieties. Between the two varieties the Plant height (cm) of capsicum was influenced significantly by two varieties at different growth stages (Figure 1 and Appendix IV and IX). At 30, 60 DAT and at harvest, the plant height was higher (29.53, 37.07 and 43.20 cm, respectively) as recorded with the variety V_1 (ASTHA F1) whereas it was lower (20.21, 32.47 and 39.13 cm, respectively) in variety V_2 (BARI capsicum-1). Similar result was also observed by Pascual-Seva *et al*. (2015) who observed variation in plant height due to varietal difference.

Effect of salinity

The plant height of capsicum was significantly affected due to different levels of salinity; it reduced with increase in salinity levels at all the stages studied, varieties (Figure 2 and Appendix IV and IX). At 30 DAT, the highest plant height (31.27 cm) was recorded from the control treatment S_0 (0 dS/m) whereas the lowest plant height (18.58 cm) was recorded from the treatment S_4 (12 dS/m). Likewise, at 60 DAT, the highest plant height (39.50 cm) was recorded from the control treatment S_0 (0 dS/m) that was statistically similar with the treatment S_1 (3 dS/m) whereas the lowest plant height (28.17 cm) was recorded from the treatment S_4 (12 dS/m).

Again, at harvest, the control treatment S_0 (0 dS/m) gave the highest plant height (49.50 cm) which was statistically similar with the treatment of S_1 (3 dS/m) whereas the lowest plant height (32 cm) was recorded from the treatment S_4 (12 dS/m) which significantly different from to other treatments. Bybordi (2010) also observed lower plant height with higher salinity condition compared to lower salinity level or control which supported the present findings.

Combined effect of variety and salinity

The treatment combinations of variety and salinity had significant effect on plant height of capsicum at different growth stages (Table 1 and Appendix IV). After 30 DAT, the highest plant height (35.80 cm) was recorded from the treatment combination of V_1S_0 that significantly differed from other treatment combinations followed by V_1S_1 whereas the lowest plant height (13.83 cm) was recorded from the treatment combination of V_2S_4. At 60 DAT, the highest plant height (42.33 cm) was recorded from the treatment combination of V_1S_0 which was statistically similar to the treatment combination of V_1S_1 whereas the lowest plant height (24.67 cm) was recorded from the treatment combination of V_2S_4 that was significantly differed from other treatment combinations.At harvest (90 DAT), the highest plant height (50.67 cm) was recorded from the treatment combination of V_1S_0 which was statistically similar to that of treatment combination of V_1S_1, V_2S_0 and V_2S_1 whereas the lowest plant height (28.67 cm) was recorded from the treatment combination of V_2S_4 which was statistically similar to the treatment combination of V_2S_3.

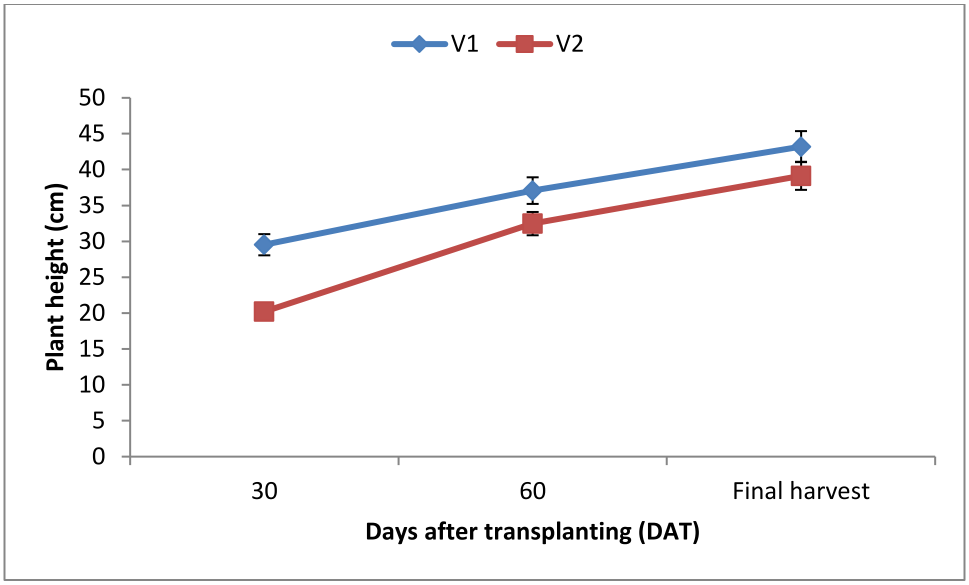

Figure 1. Effect of different capsicum varieties on plant height

V_1 = ASTHA F1, V_2 = BARI capsicum-1

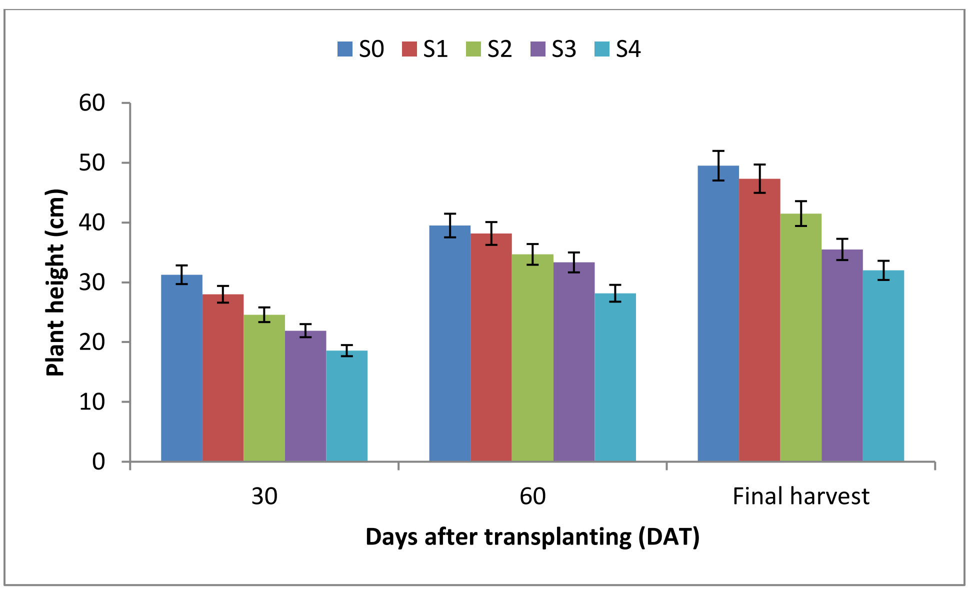

Figure 2. Effect of different salinity levels on plant height of capsicum

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

Table 1. Combined effect of different salinity levels on plant height of different capsicum varieties

Treatments	Plant height (cm)		
	30 DAT	60 DAT	Final harvest (90 DAT)
V_1S_0	35.80 a	42.33 a	50.67 a
V_1S_1	31.17 b	40.33 a	48.33 a
V_1S_2	30.17 bc	36.33 b	43.67 bc
V_1S_3	27.17 cd	34.67 bcd	38.00 d
V_1S_4	23.33 d	31.67 d	35.33 de
V_2S_0	26.73 cd	36.67 b	48.33 a
V_2S_1	24.83 d	36.00 bc	46.33 ab
V_2S_2	19.00 e	33.00 cd	39.33 cd
V_2S_3	16.67 ef	32.00 d	33.00 ef
V_2S_4	13.83 f	24.67 e	28.67 f
$LSD_{0.05}$	3.975	3.317	4.636
CV(%)	12.95	6.89	6.56

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

V_1 = ASTHA F1, V_2 = BARI capsicum-1

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

4.1.2 Number of leaves plant^{-1}

Effect of variety

Number of leaves plant^{-1} of capsicum was influenced significantly by different varieties at different growth stages (Figure 3 and Appendix V and X). At 30, 60 DAT and at harvest, higher number of leaves plant^{-1} (23.40, 38.53 and 40.44, respectively) were recorded from the variety V_1 (ASTHA F1) as compared to number of leaves plant^{-1} (20.60, 36.20 and 34.93, respectively) were recorded from the variety V_2 (BARI capsicum-1). Santos *et al*. (2019) also found similar result with the present study. Bybordi (2010) and Jamil *et al*. (2006) also observed that salinity caused significant reduction in leaf number which supported the present study.

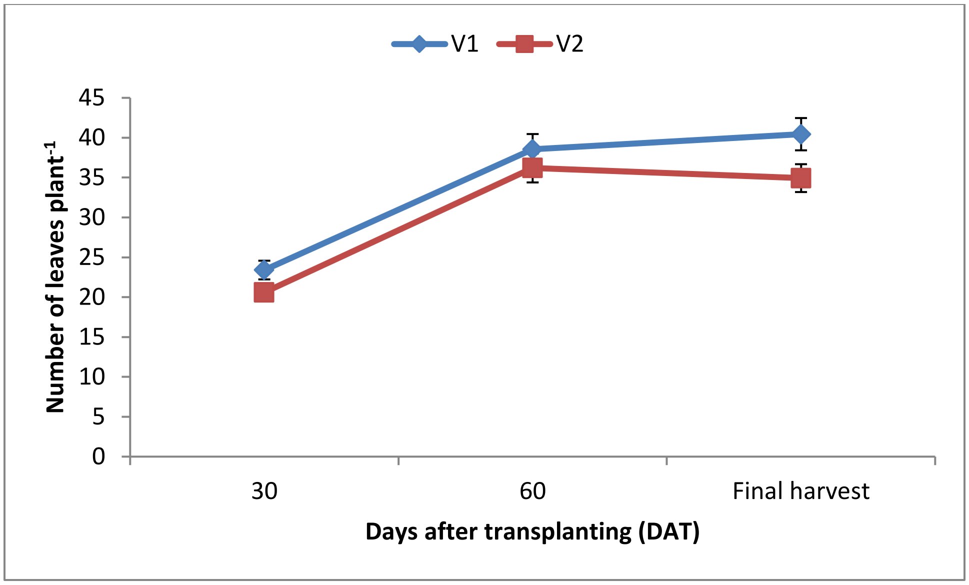

Figure 3. Effect of different capsicum varieties on number of leaves plant^{-1}

V_1 = ASTHA F1, V_2 = BARI capsicum-1

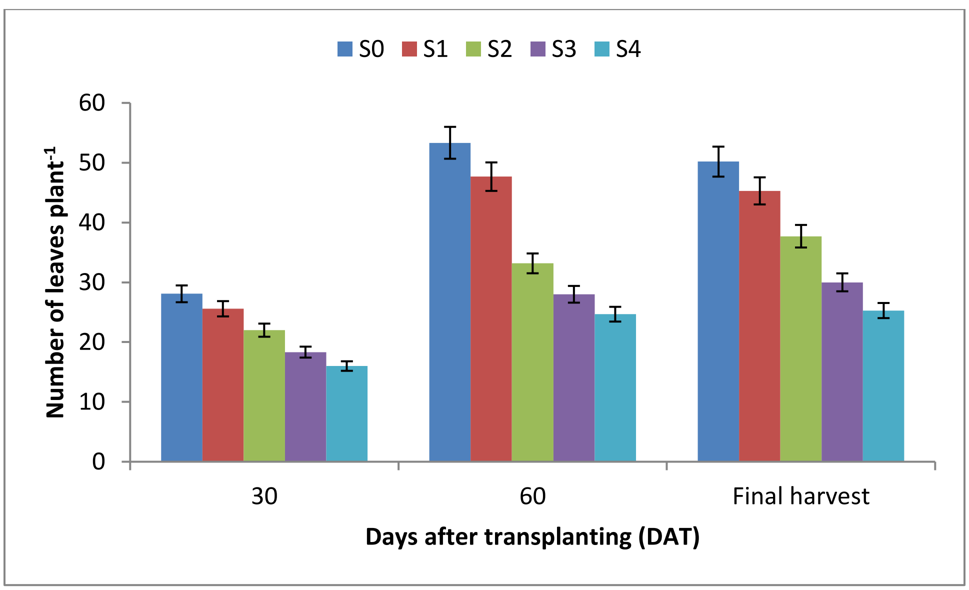

Figure 4. Effect of different salinity levels on number of leaves plant^{-1} of capsicum

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m (Final Harvest = 90 DAT)

Effect of salinity

There were significant differences among the different salinity levels in respect to number of leaves plant^{-1} of capsicum at different growth stages (Figure 4 and Appendix V and X). At 30 DAT, the highest number of leaves plant^{-1} (28.08) was recorded from the control treatment S_0 (0 dS/m) followed by S_1 (3 dS/m) treatment whereas the lowest number of leaves plant^{-1} (16.00) was recorded from the treatment S_4 (12 dS/m). Likewise, at 60 DAT, the highest number of leaves plant^{-1} (53.33) was recorded from the control treatment S_0 (0 dS/m) followed by S_1 (3 dS/m) treatment whereas the lowest number of leaves plant^{-1} (24.67) was recorded from the treatment S_4 (12 dS/m). Again, at harvest, the control treatment S_0 (0 dS/m) gave the highest number of leaves plant^{-1} (70.22) followed by the treatment of S_1 (3 dS/m) whereas the lowest number of leaves plant^{-1} (45.32) was recorded from the treatment S_4 (12 dS/m) that significantly differed to other treatments.

Table 2. Combined effect of different variety and salinity levels on number of leaves plant^{-1}

Treatments	Number of leaves plant^{-1}		
	30 DAT	60 DAT	Final harvest
V_1S_0	29.83 a	51.33 a	52.40 a
V_1S_1	27.50 ab	45.00 b	49.46 b
V_1S_2	23.00 d	29.67 d	40.63 c
V_1S_3	19.67 ef	24.33 f	31.62 e
V_1S_4	17.00 fg	21.33 gh	28.10 f
V_2S_0	26.33 bc	47.33 b	48.00 b
V_2S_1	23.67 cd	40.33 c	41.15 c
V_2S_2	21.00 de	27.67 e	34.80 d
V_2S_3	17.00 fg	23.67 fg	28.33 f
V_2S_4	15.00 g	20.00 h	22.48 g
$LSD_{0.05}$	3.002	2.616	2.258
CV(%)	12.08	4.08	9.28

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

V_1 = ASTHA F1, V_2 = BARI capsicum-1

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

High salinity can interfere with the plant's ability to take up essential nutrients from the soil. This can lead to nutrient imbalances, which are important for various growth processes, including leaf development. Fahad *et al*. (2018) also reported a reduction in the growth, yield and physiological response of *Capsicum annuum* under different saline environments.

Combined effect of variety and salinity

Different levels of salinity had significant effect on number of leaves plant^{-1} of two varieties capsicum at different growth stages (Table 2 and Appendix V). At 30 DAT, the highest number of leaves plant^{-1} (29.83) was recorded from the treatment combination of V_1S_0 which was statistically similar to the treatment combination V_1S_1 and it was lowest number of leaves plant^{-1} (15.00) in the treatment V_2S_4 which was statistically similar to the V_1S_4 and V_2S_3. At 60 DAT, the highest number of leaves plant^{-1} (51.33) was recorded from the treatment V_1S_0 that was significantly different from other treatments followed by V_1S_1 whereas the lowest number of leaves plant^{-1} (20.00) was recorded from the treatment of V_2S_4 which was statistically similar to the treatment V_1S_4. At harvest, the highest number of leaves plant^{-1} (52.40) was recorded from the treatment V_1S_0 followed by V_1S_1 and V_2S_0 whereas the lowest number of leaves plant^{-1} (22.48) was recorded from the treatment of V_2S_4 that was significantly different from that of other treatments.

4.1.3 Number of branches plant^{-1}

Effect of variety

The number of branches plant^{-1} of two varieties of capsicum at harvest did not vary significantly (Figure 5 and Appendix VI and XI). However, number of branches plant^{-1} (5.98) was recorded higher in variety V_1 (ASTHA F1) and that was lower (5.54) in variety V_2 (BARI capsicum-1). Osei *et al.* (2018) found similar result with the present study.

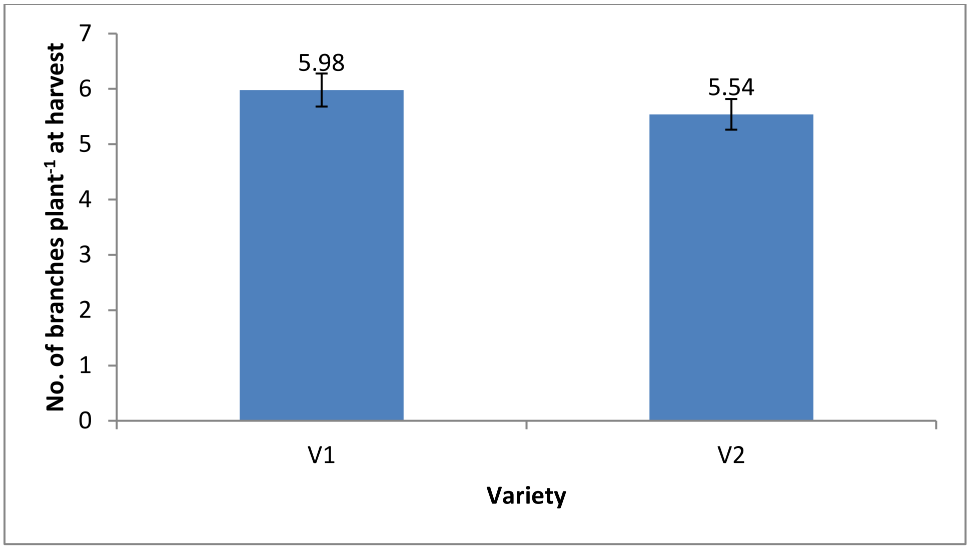

Figure 5. Effect of different capsicum varieties on number of branches plant^{-1}.

V_1 = ASTHA F1, V_2 = BARI capsicum-1

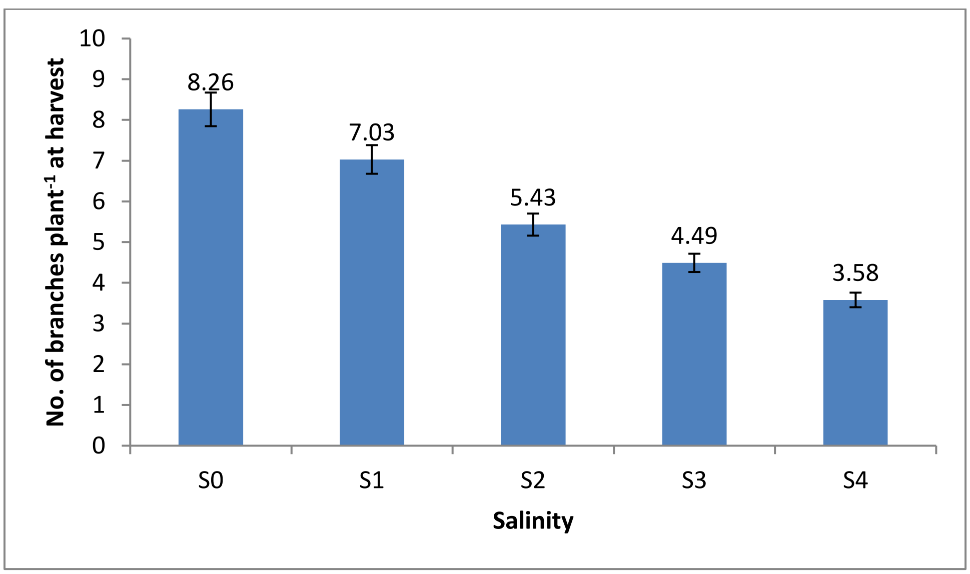

Figure 6. The effect of different salinity levels on number of branches plant^{-1} of capsicum.

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

Effect of salinity

Significant variation was observed on number of branches plant^{-1} of capsicum at harvest due to different salinity levels (Figure 6 and Appendix VI and XI). The highest number of branches plant^{-1} (8.26) was recorded from the control treatment S_0 (0 dS/m) followed by S_1 (3 dS/m). The lowest number of branches plant^{-1} (3.58) was recorded from the treatment S_4 (12 dS/m). Jamil *et al*. (2006) stated that salinity caused significant reduction in branch number of capsicum which corroborates the results of the present study.

Combined effect of variety and salinity

Significant variation was found on number of branches plant^{-1} of capsicum at harvest as affected by treatment combinations of variety and salinity (Figure 7 and Appendix VI). It appeared that the number of branches plant^{-1} decreased with increase in level of salinity.

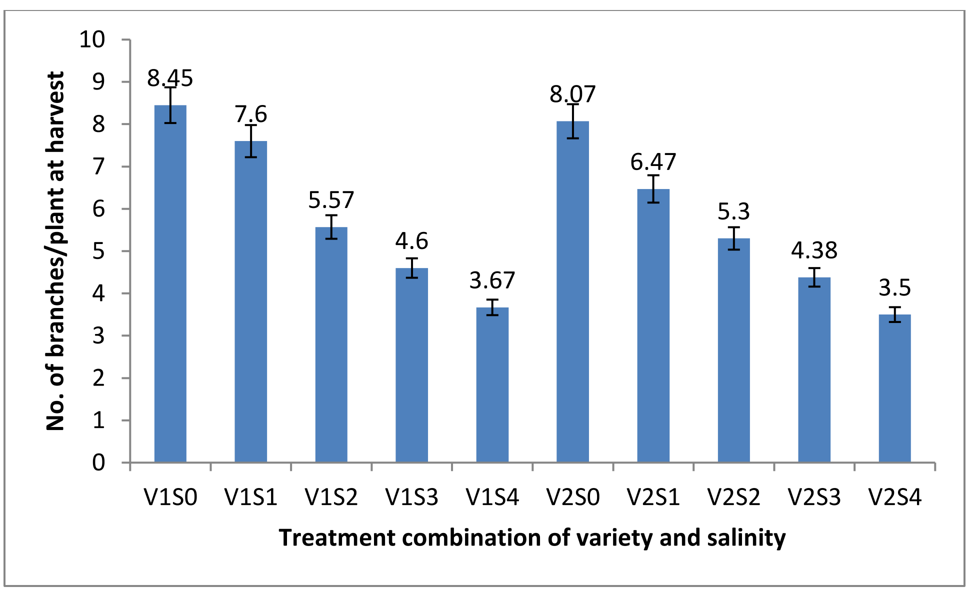

Figure 7. Combined effect of different variety and salinity levels on number of branches plant^{-1}

V_1 = ASTHA F1, V_2 = BARI capsicum-1
S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

The highest number of branches plant^{-1} (8.45) was recorded from the treatment combination of V_1S_0 which was statistically similar to the treatment combination V_2S_0 whereas the lowest number of branches plant^{-1} (3.50) was recorded from the treatment combination of V_2S_4 which was statistically similar to the treatment combination V_1S_4.

4.2 Yield contributing parameters

4.2.1 Days to first flowering

Effect of variety

There was a significant variation on number of days to 1st flowering of two varieties of capsicum (Table 3 and Appendix VI. On an average 1st flowering took place on (62.53 days) after planting in plants of variety V_1 (ASTHA F1) while in V_2 (BARI capsicum-1) 1st flowering was on (63.40 days) (n.e. one day late). This result was in agreement with the findings of Ajayi *et al*. (2017).

Effect of salinity

Significant variation was observed on days to 1st flowering of two varieties of capsicum due to different salinity levels (Table 3 and Appendix VI). The minimum days to 1st flowering (60 days) was recorded from the control treatment S_0 (0 dS/m) and the number of days to 1st flowering increased with the level of salinity. The maximum days to 1st flowering (66 days) was recorded from the highest level of salinity S_4 (12 dS/m). Similar result was also observed by Rahim *et al*., (2013).

Combined effect of variety and salinity

Significant influence was found on days to 1st flowering of capsicum affected by treatment combinations of variety and salinity (Table 3 and Appendix VI). The minimum days to 1st flowering (59.33 days) was recorded from the treatment combination of V_1S_0 that was significantly differed to other treatment combinations followed by V_2S_0. The maximum days to 1st flowering (66.33 days) was recorded from the treatment combination of V_2S_4 that was significantly differed to other treatment combinations followed by V_1S_4.

4.2.2 Number of flowers plant^{-1}

Effect of variety

The effect of variety on number of flowers plant^{-1} of capsicum was not significant (Table 3 and Appendix VI). However, the number of flowers plant^{-1} (7.90) was higher in variety V_1 (ASTHA F1) as compared to flowers plant^{-1} (7.57) that of variety V_2 (BARI capsicum-1). Ayala *et al*. (2018) found similar result with the present study.

Effect of salinity

Different salinity levels had significant effect on number of flowers plant^{-1} of capsicum (Table 3 and Appendix VI). The highest number of flowers plant^{-1} (11.52) was recorded from the control treatment S_0 (0 dS/m) which was statistically similar to the treatment S_1 (3 dS/m). The lowest number of flowers plant^{-1} (3.62) was recorded from the treatment S_4 (12 dS/m) which significantly differed from other treatments. Turhan (2011) also found similar result with the present study.

Combined effect of variety and salinity

Combined effect of variety and salinity on the number of flowers plant^{-1} of two varieties of capsicum was significantly different (Table 3 and Appendix VI). The highest number of flowers plant^{-1} (10.55) was recorded from the treatment combination of V_1S_0 which was statistically similar to the treatment combination of V_1S_1, V_1S_2, V_2S_0 and V_2S_1. The lowest number of flowers plant^{-1} (2.40) was recorded from the salinity level S_4 in BARI capsicum-1 (V_2S_4) which was statistically similar in ASTHA-1 with higher level of salinity (V_1S_4).

4.2.3 Dropping percent of capsicum flowers

Effect of variety

Dropping percentage of flower of capsicum was significantly different due to varietal difference (Table 3 and Appendix VI). The dropping of flowers was higher (43.06%) in variety V_2 (BARI capsicum-1) and it was lower (32.28%) in variety V_1 (ASTHA F1).

Effect of salinity

Application of different levels of salinity gave significant effect on dropping percentage of flower of capsicum (Table 3and Appendix VI). The highest dropping percent of flower (53.03%) was recorded from the treatment S_4 (12 dS/m) followed by S_3 (9 dS/m) whereas the lowest dropping percentage of flower (29.07%) was recorded from the control treatment S_0 (0 dS/m). The results suggested that higher salinity level increased the dropping percentage of flowers of capsicum but at the highest level of salinity the dropping of flowers did not maintain the sequence.

Combined effect of variety and salinity

Dropping percentage of flower of capsicum influenced significantly due to different salinity levels on two capsicum varieties. The dropping flower was higher in variety v_2 (BARI capsicum) as compared to v_1 (ASTHA F1) though in v_1 the dropping of flowers increased with increase in salinity levels up to S_4. But in case of v_2 the dropping of flowers increased up to S_3 and again in reduced at S_4 salinity level. (Table 3 and Appendix VI). The highest dropping of flower (69.9 %) was recorded from the treatment combination of V_1S_4 followed by V_2S_3 whereas the lowest dropping percentage of flower (27.96%) was recorded in V_1S_0.

4.2.4 Number of fruits plant^{-1}

Effect of variety

Number of fruits plant^{-1} of capsicum showed significant difference between two varieties (Table 3 and Appendix VI). The number of fruits plant^{-1} (5.35) was recorded higher in variety V_1 (ASTHA F1) and it was lower (4.31) in variety V_2 (BARI capsicum-1). Ayala *et al*. (2018) also found significant variation on number of fruits plant^{-1} among different capsicum varieties which supported the present study.

Effect of salinity

Different levels of salinity significantly affected the number of fruits plant^{-1} of capsicum (Table 3 and Appendix VI). The highest number of fruits plant^{-1} (8.17) was recorded from the control treatment S_0 (0 dS/m) followed by S_1 (3 dS/m) and the lowest number of fruits plant^{-1} (1.70) was recorded from the treatment S_4 (12 dS/m). From the result it was observed that higher salinity levels showed lower fruiting of capsicum compared to non-saline condition. Rahim *et al.*, (2013) and Turhan (2011) also observed reduced fruit number per plant with salinity stress compared to non-saline condition which supported the present result of the study.

Combined effect of variety and salinity

Different salinity levels showed significant variation in number of fruits plant^{-1} of both the capsicum varieties (Table 3 and Appendix VI). The highest number of fruits plant^{-1} (7.60) was recorded from the treatment combination of V_1S_0 which was statistically identical to the treatment combination V_1S_1 and V_2S_0. Though the lowest number of fruits plant^{-1} (0.70) was recorded from the capsicum varieties with higher level of salinity used (V_2S_4 and V_1S_4).

4.2.5 Fruit length

Effect of variety

Fruit length of two capsicum varieties was found significantly different (Table 3 and Appendix VI). The higher fruit length (74.57 mm) was recorded from the variety V_1 (ASTHA F1) and that was lower (68.71 mm) in variety V_2 (BARI capsicum-1). Ayala *et al*. (2018) reported that length of fruits differed significantly among different varieties of capsicum which supported the present findings.

Effect of salinity

Application of different levels of salinity had significant effect on fruit length of two varieties of capsicum (Table 3 and Appendix VI). The highest fruit length (78.88 mm) was recorded from the control treatment S_0 (0 dS/m) which was statistically similar to that of S_1 (3 dS/m). The lowest fruit length (63.73 mm) was recorded from the treatment S_4 (12 dS/m) which was statistically similar to the treatment S_3 (9 dS/m). It was further noted that fruit length reduced with increase in levels of salinity. Bybordi (2010) reported that there was a significant effect on fruit length due to salinity stress. Similar result was also observed by the findings of Rahim *et al*. (2013) who mentioned that salinity decreased the fruit length in chilli.

Combined effect of variety and salinity

Fruit length of capsicum influenced significantly due to different levels salinity (Table 3 and Appendix VI). It is evident from the results that the length of fruits of the variety V_1 was longer than that of V_2. The highest fruit length (80.33mm) was recorded from the treatment combination of V_1S_0. The lowest fruit length (56.13mm) was recorded from the treatment combination of V_2S_4 that was significantly differed to other treatment combinations. In both the varieties fruit length reduced with the increase in salinity levels.

Table 3. The effect of different salinity levels on yield contributing parameters of different capsicum varieties

Treatments	Yield contributing parameters					
	Days to first flowering	No. of flowers plant^{-1}	Dropping percent of flower	No. of fruits plant^{-1}	Fruit length (mm)	Fruit diameter (mm)
Varietal effect						
V_1	62.53 b	7.90	32.28 b	5.35 a	74.57 a	65.56 a
V_2	63.40 a	7.57	43.06 a	4.31 b	68.71 b	59.01 b
$LSD_{0.05}$	0.403	0.836^{NS}	1.264	0.634	0.712	0.693
CV(%)	6.24	9.98	10.56	9.95	8.43	4.39
Effect of salinity						
S_0	60.00 e	11.52 a	29.07 e	8.17 a	78.88 a	68.80 a
S_1	61.67 d	10.50 a	34.57 d	6.87 b	76.13 ab	66.08 ab
S_2	62.84 c	7.12 b	36.09 c	4.55 c	71.75 bc	62.23 bc
S_3	64.33 b	5.90 c	51.19 b	2.88 d	67.70 cd	57.47 cd
S_4	66.00 a	3.62 d	53.03 a	1.70 e	63.73 d	56.85 d
$LSD_{0.05}$	0.367	1.178	1.271	0.825	4.661	5.027
CV(%)	6.24	9.98	10.56	9.95	8.43	4.39
Combined effect of variety and salinity						
V_1S_0	59.33 h	10.55 a	27.96 i	7.60 a	80.33 a	71.90 a
V_1S_1	61.33 f	9.70 a	29.88 h	6.90 a	77.93 ab	69.57 ab
V_1S_2	62.00 e	7.23 ab	37.34 f	4.53 b	73.83 bcd	65.87 bc
V_1S_3	64.33 c	4.77 b	57.44 d	2.03 c	71.33 cde	60.67 d
V_1S_4	65.67 b	2.83 c	59.9 c	1.14 d	69.40 ef	59.80 d
V_2S_0	60.67 g	10.10 a	33.36 g	6.73 a	77.43 ab	65.70 bc
V_2S_1	62.00 e	9.30 a	47.7 e	4.83 b	74.33 bc	62.60 cd
V_2S_2	63.67 d	6.00 b	56.6 d	2.57 c	69.67 def	58.60 de
V_2S_3	64.33 c	5.03 b	64.8 b	1.73 cd	66.00 f	54.27 ef
V_2S_4	66.33 a	2.40 c	69.9 a	0.72 d	56.13 g	53.90 f
$LSD_{0.05}$	0.271	1.666	1.014	1.167	4.351	4.693
CV(%)	6.24	9.98	10.56	9.95	8.43	4.39

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

V_1 = ASTHA F1, V_2 = BARI capsicum-1

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

4.2.6 Fruit diameter

Effect of variety

Significant variation was observed on fruit diameter of two varieties of capsicum (Table 3 and Appendix VI). The fruit diameter (65.56 mm) was higher in the variety V_1 (ASTHA F1) and it was lower (59.01mm) in the variety V_2 (BARI capsicum-1). Similar result was also observed by Ayala *et al*. (2018) who observed significant variation of fruit diameter among different capsicum varieties. It might be due to differences in varietal characters.

Effect of salinity

Different levels of salinity showed significant variation on fruit diameter of two varieties of capsicum (Table 3 and Appendix VI). The highest fruit diameter (68.80mm) was recorded from the control treatment S_0 (0 dS/m) which was statistically similar to S_1 (3 dS/m) treatment whereas the lowest fruit diameter (56.85mm) was recorded from the treatment S_4 (12 dS/m) which was statistically similar to S_3 (9 dS/m). The results further indicate that with the increase in salinity levels diameter of capsicum reduced proportionately. Bybordi (2010) reported that there was a significant effect on fruit diameter due to salinity stress.

Combined effect of variety and salinity

Significant variation was found on fruit diameter of capsicum due to different treatments salinity (Table 3 and Appendix VI). The highest fruit diameter (71.90mm) was recorded from the treatment combination of V_1S_0 and the lowest fruit diameter (53.90mm) was recorded from the treatment combination of V_2S_4. If we compare separate it would have seen that diameter of V_1 was higher than that of V_2 and in both the varieties diameter of capsicum fruits reduced proportionately with higher levels of salinity. Rahim *et al*. (2013) also found similar result with the present study and reported that salinity in chilli decreased the fruit diameter.

4.3 Yield parameters

4.3.1 Single fruit weight

Effect of variety

Single fruit weight of two capsicum varieties differed significantly probably due to different varietal characters (Table 4 and Appendix VII). The single fruit weight (73.71 g) was higher in the variety V_1 (ASTHA F1) whereas lower single fruit weight (69.83 g) was in the variety V_2 (BARI capsicum-1). Arancibia *et al*. (2019) also found similar results with the present study.

Effect of salinity

Application of different levels of salinity had significant effect on single fruit weight of capsicum (Table 4 and Appendix VII). The highest single fruit weight (78.53 g) was recorded from the control treatment S_0 (0 dS/m) and that way the lowest single fruit weight (65.70 g) was recorded from the treatment S_4 (12 dS/m) which was statistically same to the treatmentS_3 (9 dS/m). Here also it was observed that single fruit weight of capsicum reduced proportionately with increase in salinity levels. Supported result was also observed by Jamil *et al*. (2006).

Combined effect of variety and salinity

The Single fruit weight of capsicum influenced significantly due to different combination of variety and salinity (Table 4 and Appendix VII). The highest single fruit weight (79.87 g) was recorded from the treatment combination of V_1S_0 that was significantly differed to other treatment combinations followed by V_2S_0. The lowest single fruit weight (62.90 g) was recorded from the treatment combination of V_2S_4 which was statistically similar to the treatment combination V_2S_3. It was further noted that in both the varieties of capsicum fruit weight reduced proportionately as the salinity levels increased up to the highest level.

4.3.2 Fruit yield plant^{-1}

Effect of variety

Fruit yield plant^{-1} between two capsicum varieties differed significantly (Table 4 and Appendix VII). The fruit yield plant^{-1} (394.54 g) was higher in the variety V_1 (ASTHA F1) and it was lower (300.96 g) in the variety V_2 (BARI capsicum-1). Similar result was also observed by Arancibia *et al*. (2019), Ayala *et al*. (2018), Osei *et al*. (2018) and Ajayi *et al*. (2017) who reported significant variation in per plant yield among different capsicum varieties.

Effect of salinity

Application of different levels of salinity showed significant variation on fruit yield plant^{-1} of capsicum (Table 4 and Appendix VII). The highest fruit yield plant^{-1} (641.59 g) was recorded from the control treatment S_0 (0 dS/m) which differed significantly from that of other treatments and the lowest fruit yield plant^{-1} (111.69 g) was recorded from the treatment S_4 (12 dS/m). The per plant yield of capsicum decreased proportionately with increase in level of salinity. Ali *et al*. (2017), Fahad *et al*. (2018), Hasanuzzaman *et al*. (2017) and Kaveh *et al.* (2011) observed significant reduction in yield of capsicum under saline conditions which supported the present findings.

Combined effect of variety and salinity

Significant variation was recorded on fruit yield plant^{-1} of capsicum influenced by different combination of variety and salinity (Table 4 and Appendix VII). The highest fruit yield plant^{-1} (607.01 g) was recorded from the treatment combination of V_1S_0 that was significantly differed to other treatment combinations followed byV_2S_0. The lowest fruit yield plant^{-1} (42.28 g) was recorded from the treatment combination of V_2S_4 which was significantly differed to other treatment combinations.

Table 4. Effect of different salinity levels on yield parameters of different capsicum varieties

Treatments	Yield parameters	
	Single fruit weight (g)	Fruit yield plant^{-1} (g)
Varietal effect		
V_1	73.71 a	394.54 a
V_2	69.83 b	300.96 b
$LSD_{0.05}$	1.033	7.394
CV(%)	10.87	8.63
Effect of salinity		
S_0	78.53 a	641.59 a
S_1	74.82 b	514.01 b
S_2	72.17 c	328.37 c
S_3	67.63 d	194.77 d
S_4	65.70 d	111.69 e
$LSD_{0.05}$	2.460	8.523
CV(%)	10.87	8.63
Combined effect of variety and salinity		
V_1S_0	79.87 a	607.01 a
V_1S_1	75.07 bc	517 b
V_1S_2	73.93 c	334.9 e
V_1S_3	71.20 d	144.53 g
V_1S_4	68.50 e	78 i
V_2S_0	77.20 b	461 c
V_2S_1	74.57 c	360.17 d
V_2S_2	70.40 de	180.92 f
V_2S_3	64.07 f	110.84 h
V_2S_4	62.90 f	45.28 **j**
$LSD_{0.05}$	2.297	6.214
CV(%)	10.87	8.63

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

V_1 = ASTHA F1, V_2 = BARI capsicum-1

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

4.4 Nutrients content in fruits of capsicum

4.4.1 Nitrogen content in fruits

Effect of variety

Nitrogen(N) content of capsicum affected significantly due to varietal performance (Table 5 and Appendix VIII). The N content was higher (1.32%) in the variety V_1 (ASTHA F1) and was lower (0.99%) in the variety V_2 (BARI capsicum-1). Genetic variation can impact various physiological traits, such as root morphology, stomatal conductance and nutrient transport mechanisms which might be the cause of significant variation on N content in fruit due to varietal difference. Different capsicum varieties have distinct genetic makeup and traits. Some varieties may be naturally better at nutrient uptake and assimilation than others. Genetic differences influence how efficiently plants take up, transport, and utilize nutrients from the soil.

Effect of salinity

Application of different levels of salinity had significant effect in N content of capsicum (Table 5 and Appendix VIII). The highest N content (1.55%) was recorded from the control treatment S_0 (0 dS/m) whereas the lowest N content (0.78%) was recorded from the treatment S_4 (12 dS/m. The nitrogen content in capsicum reduced proportionately as levels of salinity increased. Salinity stress can disrupt the uptake of nitrogen by affecting the balance of ions in the soil solution. Excessive sodium ions can interfere with the uptake of nitrate and ammonium ions which are the primary forms of nitrogen that plants absorb. Turhan, S. (2011) reported that high salinity can lead to water stress and reduced root activity, which in turn affects the uptake of nitrogen compounds.

Combined effect of variety and salinity

N content of capsicum influenced significantly due to different combination of variety and salinity (Table 5 and Appendix VIII). The highest N content (1.63%)

was recorded from the treatment combination of V_1S_0 that was significantly differed to other treatment combinations followed by V_2S_0 whereas the lowest N content (0.52%) was recorded from the treatment combination of V_2S_4 that was significantly differed to other treatment combinations. Turhan, S. (2011) reported that high salinity can lead to water stress and reduced root activity, which in turn affects the uptake of nitrogen compounds.

4.4.2 Phosphorus content in fruits

Effect of variety

Though non-significant the phosphorus (P) content of capsicum was in two different varieties (Table 5 and Appendix VIII). However, higher P content (0.144%) was in the variety V_1 (ASTHA F1) and lower P content (0.139%) was in the variety V_2 (BARI capsicum-1). Genetic variations can affect the efficiency with which a variety takes up nutrients from the soil which might be the cause of variations of P content in fruits. Prasad et al. (2009) showed that yield and quality of chilli influenced by primary and micronutrients.

Effect of salinity

Application of different levels of salinity showed decreasing P content in capsicum (Table 5 and Appendix VIII) with increase in salinity. However, the highest P content (0.173%) was in the control treatment S_0 (0 dS/m) and it was lowest P content (0.111%) was in the treatment S_4 (12 dS/m). Though the content of P decreased with rising in salinity levels and decrease in P content was not statistically significant. Salinity stress can reduce the availability of phosphorus in the soil solution. High salt concentrations can create a competitive effect, as the excess ions can hinder the diffusion of phosphorus ions to the plant roots. Prasad et al. (2009) showed that yield and quality of chilli influenced by primary and micronutrients.

Combined effect of variety and salinity

P content of capsicum was not influenced significantly due to different combination of variety and salinity (Table 5 and Appendix VIII). However, the highest P content (0.177%) was recorded from the treatment combination of V_1S_0 whereas the lowest P content (0.108%) was recorded from the treatment combination of V_2S_4. Here, P content reduced proportionately in both the varieties as level of salinity increased.

4.4.3 Potassium (K) content in fruits

Effect of variety

Non-significant variation was recorded on K content of capsicum influenced by different variety (Table 5 and Appendix VIII). However, K content was higher (0.119 meq/100g) in the variety V_1 (ASTHA F1) and K content was lower (0.113 meq/100g) in the varietyV_2 (BARI capsicum-1). Varietal differences can influence how nutrients are transported within the plant and allocated to various plant parts, including fruits. Prasad et al. (2009) showed that yield and quality of chilli influenced by primary and micronutrients.

Effect of salinity

Application of different levels of salinity gave non-significant effect on K content of capsicum (Table 5 and Appendix VIII). However, the highest K content (0.126 meq/100g) was recorded from the control treatment S_0 (0 dS/m) whereas the lowest K content (0.104 meq/100g) was recorded from the treatment S_4 (12 dS/m). Salinity stress can lead to an imbalance of potassium ions in plant tissues due to the presence of excess sodium ions. This can disrupt potassium uptake and translocation. Sodium ions can replace potassium ions in certain cellular functions, affecting enzyme activities and cellular integrity. Prasad and kumar et al. (2009) showed that yield and quality of chilli influenced by primary and micronutrients.

Combined effect of variety and salinity

K content of capsicum was not influenced significantly due to different combination of variety and salinity (Table 5 and Appendix VIII). However, the highest K content (0.130 meq/100g) was recorded from the treatment combination of V_1S_0 whereas the lowest K content (0.103 meq/100g) was recorded from the treatment combination of V_2S_4.

Table 5. Effect of different salinity levels on N%, P%, Na% and K (meq/100 g) content of two capsicum varieties

Treatments	Nutrient content of capsicum			
	N (%)	P content (%)	K content (meq/100 g)	Na (%)
Varietal effect				
V_1	1.32 a	0.144	0.119	2.34 a
V_2	0.99 b	0.139	0.113	2.12 b
$LSD_{0.05}$	0.116	0.032^{NS}	0.027^{NS}	0.211
CV(%)	5.37	2.91	2.56	3.14
Effect of salinity				
S_0	1.55 a	0.173	0.126	0.16e
S_1	1.35 b	0.163	0.119	1.91 d
S_2	1.07 c	0.140	0.118	2.36 c
S_3	1.04 c	0.117	0.110	3.09 b
S_4	0.78 d	0.111	0.104	3.66 a
$LSD_{0.05}$	0.112	0.101^{NS}	0.103^{NS}	0.347
CV(%)	5.37	2.91	2.56	3.14
Combined effect of variety and salinity				
V_1S_0	1.63 a	0.177	0.130	0.17 f
V_1S_1	1.45b	0.168	0.120	2.01 e
V_1S_2	1.26c	0.139	0.122	2.53 d
V_1S_3	1.24c	0.119	0.116	3.20 c
V_1S_4	1.04 d	0.114	0.106	3.81 a
V_2S_0	1.47 b	0.169	0.122	0.15 g
V_2S_1	1.25c	0.159	0.118	1.81 f
V_2S_2	0.87 e	0.142	0.113	2.18 e
V_2S_3	0.84 e	0.114	0.104	2.97 c
V_2S_4	0.52 f	0.108	0.103	3.51 b
$LSD_{0.05}$	0.102	0.180^{NS}	0.094^{NS}	0.241
CV(%)	5.37	2.91	2.56	3.14

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

NS= non-significant, V_1 = ASTHA F1, V_2 = BARI capsicum-1

S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

4.4.4 Sodium content in fruits

Effect of variety

The Sodium (Na) content of capsicum affected significantly due to varietal performance (Table 5 and Appendix VIII). The Na content (2.34%) was higher in the variety V_1 (ASTHA F1) whereas it was lower Na content (2.12%) in the variety V_2 (BARI capsicum-1). The content of sodium was higher in ASTHA F1 as compared to BARI capsicum-1 and the difference was statistically significant at 0.05% level of probability. The variation in Na content in capsicum (pepper) fruit due to varietal differences can be attributed to genetic and physiological variations among different pepper varieties. Sodium accumulation is influenced by various factors, including the genetics of the plant, its ability to regulate sodium uptake and transport, and its overall response to salinity stress. Similar result was also observed by Niu *et al.* (2010).

Effect of salinity

Application of different levels of salinity gave significant effect on Na content of capsicum (Table 5 and Appendix VIII). The highest Na content (3.66%) was recorded from the treatment S_4 (12 dS/m) whereas the lowest Na content (1.64%) was recorded from control treatment S_0 (0 dS/m) which was statistically similar to S_1 (3 dS/m). Similar result was also observed by Niu *et al.* (2010). Who studied eight chilli pepper varieties to the response of saline irrigation water. When sodium levels in the soil solution are elevated, plants might absorb more sodium alongside other ions due to the osmotic pressure created by the high salt concentration. Sodium ions can sometimes compete with potassium ions for uptake by plant roots. As sodium levels increase, the competitive effect can lead to higher sodium uptake.

Combined effect of variety and salinity

Na content of capsicum influenced significantly due to different combinations of variety and salinity (Table 5 and Appendix VIII). The highest Na content (3.81%) was recorded from the treatment combination of V_1S_4 that was significantly differed to other treatment combinations followed by V_2S_4.Whereas the lowest Na content (0.15%) was recorded from the treatment combination of V_2S_0.

CHAPTER V

SUMMARY AND CONCLUSION

Two different varieties of capsicum had significant effect on most of the parameters. At 30, 60 DAT and at the time of final harvest, the variety V_1 (ASTHA F1) gave the higher plant height (29.53, 37.07 and 43.20 cm) respectively and number of leaves plant^{-1} (23.40, 38.53 and 40.44, respectively) whereas the lower plant height (20.21, 32.47 and 39.13 cm, respectively) and number of leaves plant^{-1} (20.60, 36.20 and 34.93, respectively) was found from the variety V_2 (BARI capsicum-1). Again, number of branches plant^{-1} and number of flowers plant^{-1} were not affected significantly by different varieties of capsicum while the variety V_1 (ASTHA F1) gave the higher number of fruits plant^{-1} (5.35), fruit length (74.57 mm) and fruit diameter (65.56 mm), single fruit weight (73.71 g) and fruit yield plant^{-1} (394.54 g) whereas the variety V_2 (BARI capsicum-1) gave the lower number of fruits plant^{-1} (4.31), fruit length (68.71 mm) and fruit diameter (59.01 mm), single fruit weight (69.83 g) and fruit yield plant^{-1} (300.96 g). The minimum days to first flowering (62.53 days) and lower dropping percent of flower (32.28 %) were recorded from V_1 (ASTHA F1) variety whereas maximum days to first flowering (63.40 days) and higher dropping percent of flower (43.06 %) were recorded from V_2 (BARI capsicum-1) variety. In case of nutrient content of fruit, the two varieties did not show significant variation on P and K content but N and Na content varied significantly by varieties of capsicum. V_1 (ASTHA F1) gave higher N and Na content (1.32% and 2.34%, respectively) whereas V_2 (BARI capsicum-1) showed the lowest (0.99% and 2.12%, respectively) content.

Different salinity treatments to capsicum had significant effect on most of the parameters. At 30, 60 DAT and at the time of final harvest, the control treatment S_0 (0 dS/m) gave the highest plant height (31.27, 39.50 and 49.50 cm) respectively and number of leaves plant^{-1} (28.08, 53.33 and 50.18, respectively) followed by S_1 (3 dS/m) whereas the lowest plant height (18.58, 28.17 and 32.00 cm, respectively) and number of leaves plant^{-1} (16.00, 24.67 and 25.28, respectively) were found from the treatment S_4 (12 dS/m). Plant height and number of leaves plant^{-1} decreased with the increasing of salinity levels. Again, the highest number of branches plant^{-1} (8.26), number of flowers plant^{-1} (11.52), number of fruits plant^{-1} (8.17), fruit length (78.88 mm), fruit diameter (68.80 mm), single fruit weight (78.53 g) and fruit yield plant^{-1} (641.59 g) were achieved by the control treatment S_0 (0 dS/m) while the second highest result for the respective parameters were recorded from S_1 (3 dS/m) treatment whereas the treatment S_4 (12 dS/m) gave the lowest number of branches plant^{-1} (3.58), number of flowers plant^{-1} (3.62), number of fruits plant^{-1} (1.70), fruit length (63.73 mm), fruit diameter (56.85 mm), single fruit weight (65.70 g) and fruit yield plant^{-1} (111.69 g). The minimum days to first flowering (60.00 days) and lowest dropping percent of flower (29.07 %) were recorded from control treatment S_0 (0 dS/m) whereas maximum days to first flowering (66.00 days) was recorded from S_4 (12 dS/m) treatment and the highest dropping percent of flower (53.03%) were recorded from the treatment S_4 (12 dS/m). In case of nutrient content of fruit, different salinity treatment did not show significant variation on P and K content but N and Na content varied significantly. Control treatment S_0 (0 dS/m) gave the highest N content (1.55%) followed by S_1 (3 dS/m) and treatment S_4 (12 dS/m) gave the highest Na content of fruit (3.66%) whereas the lowest N content (0.78%) was recorded from S_4 (12 dS/m) treatment and the lowest Na content of fruit (0.16%) was found from control treatment S_0 (0 dS/m).

Treatment combination of variety and salinity showed significant influence on different study parameters. Results indicated that at 30, 60 DAT and at the time of final harvest, the treatment combination V_1S_0 gave the highest plant height (35.80, 42.33 and 50.67 cm, respectively) and number of leaves plant^{-1} (29.83, 51.33 and

52.40, respectively) followed by V_1S_1 whereas the lowest plant height (13.83, 24.67 and 28.67 cm, respectively) and number of leaves plant^{-1} (15.00, 20.00 and 22.48, respectively) was found from the treatment combination V_2S_4. Again, the highest number of branches plant^{-1} (8.45), number of flowers plant^{-1} (10.55), number of fruits plant^{-1} (7.60), fruit length (80.33 mm), fruit diameter (71.90 mm), single fruit weight (79.87 g) and fruit yield plant^{-1} (607.01 g) were achieved by the treatment combination of V_1S_0 whereas the treatment combination V_2S_4 gave the lowest number of branches plant^{-1} (3.50), number of flowers plant^{-1} (2.40), number of fruits plant^{-1} (0.72), fruit length (56.13 mm), fruit diameter (54.27 mm), single fruit weight (62.90 g) and fruit yield plant^{-1} (45.28 g). The minimum days to first flowering (59.33 days) and lowest dropping percent of flower (27.96 %) were recorded from V_1S_0 whereas maximum days to first flowering (66.33 days) was recorded from V_2S_4 and the highest dropping percent of flower (69.9%) were recorded from V_2S_4. In case of nutrients content of fruit, different treatment combination of variety and salinity showed non-significant variation on P and K content but N and Na content varied significantly. Treatment combination of V_1S_0 gave highest N (1.63%) and V_1S_4 gave the highest Na content (3.81%) whereas V_2S_4 treatment combination showed the lowest N content (0.52%) but the lowest Na content of fruit was recorded from V_2S_0 (1.50%).

From the above result, the following conclusions may be drawn:

1. The variety V_1 (ASTHA F1) can be considered as the best regarding growth, yield contributing parameters, yield and nutrient content of capsicum compared to the variety V_2 (BARI capsicum-1).
2. The control treatment S_0 (0 dS/m) showed the best performance on growth, yield contributing parameters, yield and nutrient content of capsicum followed by S_1 (3 dS/m). Yield contributing parameters and yield performance was decreased with increasing of salinity and the highest

salinity treatment S_4 (12 dS/m) showed least performance on yield contributing parameters and yield of capsicum.

3. Among 10 treatment combinations of variety and salinity, V_1S_0 (ASTHA F1 with no salinity) was best regarding higher results on growth, yield contributing parameters and yield whereas V_2S_4 (BARI capsicum-1 with 12 dS/m) gave least performance.

Recommendation

Further research works with different varieties at different regions including saline areas of the country are needed to be carried out for the confirmation of the present findings.

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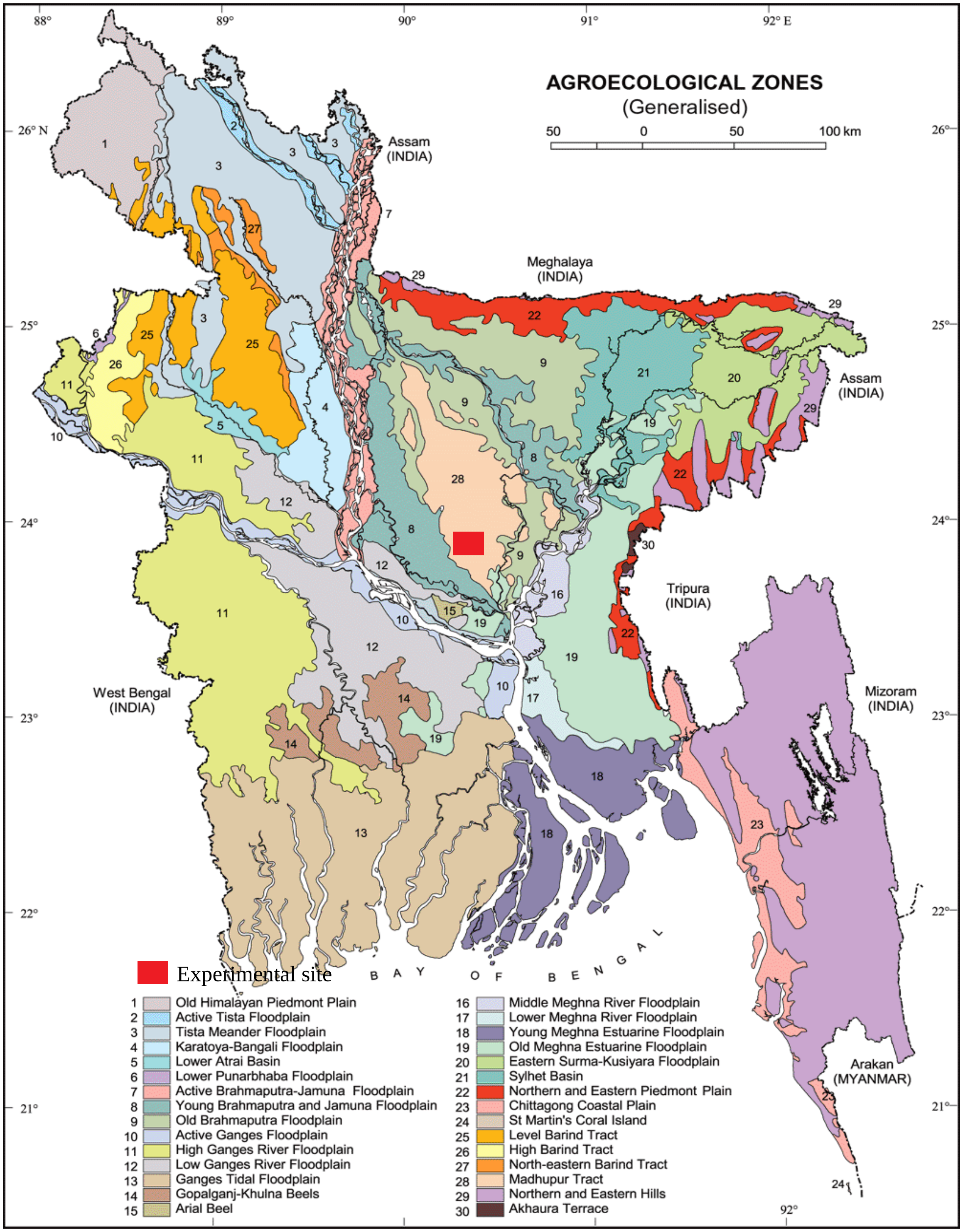
APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from November 2021 to March 2022.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2021	November	28.60	8.52	18.56	56.75	14.40
2021	December	25.50	6.70	16.10	54.80	0.0
2022	January	23.80	11.70	17.75	46.20	0.0
2022	February	22.75	14.26	18.51	37.90	0.0
2022	March	35.20	21.00	28.10	52.44	20.4

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

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

AppendixIV. Effect of different salinity levels on plant height of different Capsicum varieties

Sources of variation	Degrees of freedom	Mean square of plant height (cm)		
		30 DAT	60 DAT	Final harvest
Replication	3	2.457	3.613	4.933
Factor A	1	105.53*	158.70*	124.03*
Factor B	4	148.56*	119.38*	335.58*
AB	4	5.182**	4.617**	5.617**
Error	18	5.370	3.744	7.304

NS = Nonsignificant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Effect of different salinity levels on number of leaves plant^{-1} of different Capsicum varieties

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		30 DAT	60 DAT	Final harvest
Replication	3	3.775	3.733	3.475
Factor A	1	58.800*	40.833*	211.36*
Factor B	4	148.93*	941.53*	537.24*
AB	4	1.071**	2.667**	4.271*
Error	18	3.062	2.326	1.733

NS = Nonsignificant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Effect of different salinity levels on yield contributing parameters of different Capsicum varieties

Sources of variation	Degrees of freedom	Mean square of Yield contributing parameters						
		No. of branches plant at harvest	Days to first flowering	No. of flowers/ plant	Dropping percent of flower	No. of fruits/ plant	Fruit length (mm)	Fruit diameter (mm)
Replication	3	0.353	0.561	0.561	0.924	0.137	33.921	3.657
Factor A	1	1.408^{NS}	0.817**	0.817^{NS}	7257*	8.112*	256.96*	321.44*
Factor B	4	21.47*	14.22*	64.07*	87.36*	43.41*	226.06*	164.44*
AB	4	0.239**	2.31*	0.244**	3.71*	1.339**	41.259*	0.470**
Error	18	0.200	0.436	0.943	0.611	0.463	6.434	7.486

NS = Nonsignificant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Effect of different salinity levels on yield parameters of different Capsicum varieties

Sources of variation	Degrees of freedom	Mean square of Yield parameters	
		Single fruit weight (g)	Fruit yield $plant^{-1}$ (g)
Replication	3	1.849	6.211
Factor A	1	113.29*	354.88*
Factor B	4	163.71*	279.64*
AB	4	9.960*	6.612**
Error	18	1.793	11.271

NS = Nonsignificant   * = Significant at 5% level   ** = Significant at 1% level

Appendix VIII. Effect of different salinity levels on N, P, K and Na content of different Capsicum varieties

Sources of variation	Degrees of freedom	Mean square of Nutrient content of capsicum			
		N (%)	P content (ppm)	K content (meq/100 g)	Na (%)
Replication	3	0.327	0.001	0.001	0.264
Factor A	1	8.52*	0.001^{NS}	0.001^{NS}	18.94*
Factor B	4	126.39*	0.005^{NS}	0.002^{NS}	41.36*
AB	4	1.073**	0.001^{NS}	0.001^{NS}	1.311**
Error	18	0.072	0.003	0.001	0.231

NS = Nonsignificant   * = Significant at 5% level   ** = Significant at 1% level

Appendix IX. Effect of different salinity levels on plant height of different capsicum varieties

Treatments	Plant height (cm)		
	30 DAT	60 DAT	Final harvest
Varietal effect			
V_1	29.53 a	37.07 a	43.20 a
V_2	20.21 b	32.47 b	39.13 b
$LSD_{0.05}$	2.147	1.589	1.322
CV(%)	12.95	6.89	6.56
Effect of salinity			
S_0	31.27 a	39.50 a	49.50 a
S_1	28.00 b	38.17 a	47.33 a
S_2	24.58 c	34.67 b	41.50 b
S_3	21.92 c	33.33 b	35.50 c
S_4	18.58 d	28.17 c	32.00 d
$LSD_{0.05}$	2.811	2.347	3.278
CV(%)	12.95	6.89	6.56

V_1 = ASTHA F1, V_2 = BARI capsicum-1, S_0 = 0 dS/m, S_1 = 3 dS/m (10.73 g NaCl/6 L water), S_2 = 6 dS/m (26.82 g NaCl/6 L water), S_3 = 9 dS/m (40.22 g NaCl/6 L water), S_4 = 12 dS/m (53.64 g NaCl/6 L water)

Appendix X. Effect of different salinity levels on number of leaves plant^{-1} of different capsicum varieties

Treatments	Number of leaves plant^{-1}		
	30 DAT	60 DAT	Final harvest
Varietal effect			
V_1	23.40 a	38.53 a	60.48 a
V_2	20.60 b	36.20 b	54.97 b
$LSD_{0.05}$	1.244	0.714	1.371
CV(%)	12.08	4.08	9.28
Effect of salinity			
S_0	28.08 a	53.33 a	70.22 a
S_1	25.58 b	47.67 b	65.33 b
S_2	22.00 c	33.17 c	57.75 c
S_3	18.33 d	28.00 d	50.00 d
S_4	16.00 e	24.67 e	45.32 e
$LSD_{0.05}$	2.123	1.850	1.597
CV(%)	12.08	4.08	9.28

V_1 = ASTHA F1, V_2 = BARI capsicum-1, S_0 = 0 dS/m, S_1 = 3 dS/m, S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m

Appendix XI. Effect of different salinity levels on number of branches plant^{-1} at harvest of different capsicum varieties

Treatments	No. of branches plant at harvest
Varietal effect	
V_1	5.98
V_2	5.54
$LSD_{0.05}$	0.572^{NS}
CV(%)	7.77
Effect of salinity	
S_0	8.26 a
S_1	7.03 b
S_2	5.43 c
S_3	4.49 d
S_4	3.58 e
$LSD_{0.05}$	0.543
CV(%)	7.77

V_1 = ASTHA F1, V_2 = BARI capsicum-1, S_0 = 0 dS/m, S_1 = 3 dS/m , S_2 = 6 dS/m, S_3 = 9 dS/m, S_4 = 12 dS/m