

GROWTH AND YIELD OF SQUASH AS INFLUENCED BY ETHREL

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JUNE, 2020

**GROWTH AND YIELD OF SQUASH
AS INFLUENCED BY ETHREL**

BY

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REG. NO. : 18-09036

A Thesis

*Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree of*

MASTER OF SCIENCE

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2020

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CERTIFICATE

This is to certify that thesis entitled, “**GROWTH AND YIELD OF SQUASH AS INFLUENCED BY ETHREL**” submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **HORTICULTURE** embodies the result of a piece of bona fide research work carried out by **JAYATI BISWAS CHAITI**, Registration No. **18-09036** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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**DEDICATED
TO
BELOVED PARENTS
AND SISTER**

ACKNOWLEDGEMENTS

All praises and thanks are due to the Supreme Ruler of the universe, the Almighty Allah for His grace bestowed upon the author for accomplishment of this research study.

*The authoress expresses the deepest sense of respect and heartiest gratitude to her respectable supervisor **Prof. Dr. Md. Ismail Hossain**, Department of Horticulture, Sher-e-Bangla Agricultural University for his efficient and scholastic guidance, constructive criticism, valuable suggestions and immense help to carry out the research work towards the successful completion and preparation of the thesis.*

*The authoress expresses her sincere appreciation and heartfelt gratitude to her co-supervisor **Prof. Dr. Mohammad Humayun Kabir**, Department of Horticulture, Sher-e-Bangla Agricultural University, for his valuable suggestions, constant cooperation, inspiration and sincere advice to improve the quality of the thesis.*

*Cordial thanks to **Prof. Dr. Mohammad Jahedur Rahman**, Chairman, Department of Horticulture and all respected teachers of the Department of Horticulture, Sher-e-Bangla Agricultural University for their help and co-operation during the study and research.*

The authoress is grateful to all those people who contributed to this research work although it is not possible to mention all of them by their names.

Last but not the least, the authoress expresses her immense indebtedness and the deepest senses of gratitude to her beloved parents and younger sister who sacrificed all their happiness during the whole study period. The authoress is grateful to all the respondents in the study area for their cooperation and help in accomplishing the objectives of this research work. Finally, the authoress extends her heartfelt thanks and gratitude to all of her relatives for their inspiration, blessing and encouragement that opened the gate of her higher study.

The authoress

GROWTH AND YIELD OF SQUASH AS INFLUENCED BY ETHREL

ABSTRACT

A field experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2018 to March 2019 to study the effects of variety and different doses of ethrel on the growth and yield of squash. The experiment had two factors (Varieties: V_1 = GS-1, V_2 = Cherub and V_3 = Cheonlima and different doses of ethrel: E_0 = 0 ppm (control), E_1 = 250 ppm and E_2 = 500 ppm). The experiment was laid out in the Randomized Complete Block Design with three replications. Significant variations were observed for most of the studied traits as influenced by different varieties, levels of ethrel and their interaction too. But in case of number of leaves and stem diameter at 15 DAT, the interaction effects were non-significant. The highest fruit yield (37.34 t ha^{-1}) was found from the variety V_1 (GS-1) whereas the lowest fruit yield (20.77 t ha^{-1}) was found from the variety V_2 (Cherub). The highest fruit yield (35.93 t ha^{-1}) was found from E_1 (250 ppm ethrel) where the lowest (22.88 t ha^{-1}) was found from E_2 (500 ppm ethrel). The highest fruit yield ha^{-1} (45.37 t) was found from the combination V_1E_1 (variety GS-1 with 250 ppm ethrel) but the lowest fruit yield ha^{-1} (17.23 t) was found from the combination V_2E_2 (variety Cherub with 500 ppm ethrel). The combination V_1E_1 (variety GS-1 with 250 ppm ethrel) was found the best one for the cultivation of squash.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
BBS	=	Bangladesh Bureau of Statistics
BARI	=	Bangladesh Agricultural Research Institute
Ca	=	Calcium
CCC	=	Chlorocholine Chloride
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAT	=	Days After Transplanting
DMRT	=	Duncan's Multiple Range Test
<i>et al.</i> ,	=	And others
e.g.	=	<i>exempli gratia</i> (L), for example
E	=	Ethrel
FAO	=	Food and Agriculture Organization of the United Nations
g	=	Gram (s)
GA ₃	=	Gibbrellic Acid
HYV	=	High Yielding Variety
i.e.	=	<i>id est</i> (L), that is
IAA	=	Indole-3-Acetic Acid
IBA	=	Indole-3-Butyric Acid
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
m ²	=	Meter squares
mg	=	Milli-gram

ml	=	Milli-litre
mm	=	Milli-meter
M.S.	=	Master of Science
NAA	=	Naphthalene Acetic Acid
NPK	=	Nitrogen, Phosphorus and Potassium
No.	=	Number
P	=	Phosphorus
R	=	Replication
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
t	=	Ton
TSS	=	Total Suspended Solids
USA	=	United States of America
V	=	Variety
WHO	=	World Health Organization
°C	=	Degree Celsius
%	=	Percentage

CHAPTER I

INTRODUCTION

Squash (*Cucurbita pepo* L.) belongs to the family Cucurbitaceae and is grown throughout the world in both temperate and tropical climatic zones. It is commonly known as zucchini and is part of the gourd family. They are native to Central America and Mexico. Various cultivars of *Cucurbita pepo* are called summer squash, vegetable marrow, zucchini, and spaghetti squash (Purseglove, 1968). Among the different winter cucurbit vegetables, sweet gourd or pumpkin is a tender tendril bearing and vine like plant from genus *Cucurbita* belonging to the family Cucurbitaceae of gourd family. There are three common types of pumpkin worldwide, namely *Cucurbita pepo*, *Cucurbita maxima* and *C. moschata* and were originally domesticated in Mexico, South America, and the eastern U.S. (Tecson, 2001). Squash commonly known in the Visayan language as *kalabasa*, have long been used in the Philippines as fleshy vegetables. Those belong to the plant family that includes melon and cucumber, come in many varieties, (Pears, 2004 and Kubo *et al.*, 2010).

However, in Bangladesh, this crop is relatively new but increasingly gaining high levels of economical importance both in generating income and provision of nutritional value. Squash has various health benefits to humans as well as medicinal potentials (Bannayan *et al.*, 2011). It is rich in nutrients and bioactive compounds contents such as phenolics, flavonoids, vitamins (including β -carotene, vitamin A, vitamin B₂, α -tocopherol, vitamin C and vitamin E), amino acids, carbohydrates and minerals (especially potassium), and it is low in energy content (about 17 Kcal/100 g of fresh pumpkin) and has large amount of fibers (Tamer *et al.*, 2010). It has various medicinal effects comprising of anti-diabetic, anti-hypertensive, anti-tumor, anti-mutagenic, immunomodulating, anti-bacterial, anti-hypercholesterolemic, intestinal anti-parasitic, antalgic, and anti-

inflammation effects, and the utilization possibilities of Cucurbitaceous crops have been reported by Kostalova *et al.*, (2009).

Squash is now cultivated in all over the world; pumpkins, squash and gourds are planted in 2044055 ha area of land that was able to be harvested on an average of 27655330 ton in 2018. It is usually grown in home gardens and commercial scale for its immature fruits, young shoots, flowers, and seeds. Day by day the squash production is increasing in Bangladesh as squash has great demand. According to the statistical data, Bangladesh ranks 16th position in quantity of squash, pumpkin and gourd production and the quantity was 303,073 tons. In the same year, the area harvested of pumpkins, squash and gourds was 27,990 ha and it ranked 12 the positions (FAOSTAT, 2019).

Variety is an important factor for successful crop yield. An improved variety represents higher yield than wild one. Generally nutrient requirement is determined by the variety of crops. High yielding variety requires more nutrients than the local or wild variety. Generally it depends on its vegetative and reproductive characters and it was also mentioned that vegetable variety and history of fertilizer use are important factors to be considered in the development of a soil nutrient management program (Huang, 2006).

Squash plants are very sensitive to agroclimatic factors like photoperiod and temperature during critical development stages which influences plant growth and yield (Bannayan *et al.*, 2011). In this respect, genotypes behave variably under different environmental conditions and most crop cultivars are adapted to temperature where it is the major factor affecting on their distributions (Moursy *et al.*, 2014). Numerous studies on the cultivars of cucurbitaceae members family indicated that flowering characters, yield and its components, as well as fruit physical and chemical parameters have highly variation depending on their genetic make-up and/or environmental factors (Marie *et al.*, 2011; Yoldes, 2014;

Esho and Saeed, 2016 and 2017; Hassan *et al.*, 2016, Mousa and Al-Qurashi, 2017 as well as Kumar and Sharma, 2018).

Squash production is very low compared to other vegetables. So, there is a huge scope to increase the production by following some management practices. Squash is a monoecious plant, naturally, inducing greater number of male flowers than the female flowers. This flowering behavior is not advantageous and economical, because it results in lower fruit set and yield. To have the higher yield, the male and female flower ratio needed to be synchronized. Maleness and femaleness can usually be altered by the application of plant growth regulators (Krishnamoorthy, 1981).

Ethrel, a plant growth regulator containing the active substance ethephon is used to major horticultural crops and cereals to increase the number of female flowers. Exogenous application with ethylene-releasing compounds such as Ethrel or ethephon is among the growth regulator which could be used in inducing the femaleness in cucurbit crops, with a concentration ranged from 100 to 500 mg l⁻¹ as reported by Rudich *et al.* (1972), Arora *et al.* (1985), Atta-Aly (1992), El-Zawily and Moustafa (1997) and Mibus and Tatlioglu (2004). Many workers had reported that the ratio of female to male flowers in cucurbit plants is valuable and very important trait since total fruit yield depend upon this ratio (Atta-Aly, 1998; Abd-El-Fattah and Sorial, 2000; Mibus and Tatlioglu, 2004 and Santos *et al.*, 2006). Again spraying the seedlings with ethrel in early stage might due to enhancing root growth during germination and early growing stage, which reflected on vigor shoot growth thus increasing sex ratio female to male flowers (Glala *et al.*, 2012). The seedlings of poinsettee variety of cucumber sprayed with ethrel (400 mg l⁻¹) at four to six leaf stage significantly increased the number of female flowers per plant (35.23) and reduced the sex ratio (3.69) compared to control 19.8 and 224.5, respectively (Vadigeri *et al.*, 2001).

Some authors (Gad *et al.*, 1993, Yongan *et al.*, 2002, Manzano *et al.*, 2011, Ezzo *et al.*, 2012, Shafeek *et al.*, 2016 and Fekry, 2016) claimed that the total yield and fruit quality were enhanced as a result of spraying ethrel at the early stage of seedlings. Moreover, the increasing of squash fruit yield may be attributed to the higher ethylene production as a result to spraying ethrel which is due to increase in the number of female flowers on squash.

Considering the above factors, the present study was undertaken with the following three objectives:

- i. To identify the suitable cultivar for higher yield of squash;
- ii. To select the optimum level of ethrel for the better growth and yield of squash; and finally
- iii. To find out the suitable combination of cultivar and ethrel for the higher yield of squash.

CHAPTER II

REVIEW OF LITERATURE

Squash is becoming an important vegetable crop worldwide and receiving much attention of the researchers throughout the world to develop its suitable production technique. Among various research works, investigations have been made in various parts of the world to select the suitable variety and different dose of ethrel application. In maximum case, we observed these techniques for *Cucurbitaceae* family crops as definitely squash is not so much an old crop in the world. However, the combined effects of these production practices have not been defined clearly. In Bangladesh, squash is well known to most of the vegetable lovers though cultivation has not started in wide range. There has not many studies on the influence of different varieties and different dose of ethrel on growth and yield of squash. Relevant available information in this connection has been described in this chapter.

2.1 Literatures on variety

Salma (2019) evaluated to study the effect of three cultivars of squash (Eskandarany, Revera and Azyad) and foliar spray treatments with, yeast extract at the rate of 3 and 6gl⁻¹, as well as potassium silicate at the rate of 2 and 4gl⁻¹ plus control (tap water) and their interactions on flowering expression, i.e., number of male and female flowers plant⁻¹, sex ratio and femalness percentage, yield and its components (number of fruits plant⁻¹, fruit fresh weight, and dry matter percentage, total fruit yield plot⁻¹ and relative yield), as well as fruit quality, i.e., fruit physical characters (both of fruit length and diameter) and fruit chemical composition (nitrogen, phosphorus and potassium content, protein and total carbohydrates percentage). Results showed the superiority of the two tested cultivars Azyad and Revera at all studied characteristics compared with Eskandarany cv. Spraying with yeast extract or potassium silicate significantly increased most parameters of flowering, fruit yield and quality attributes of

squash than control treatment . Moreover, spraying plants with potassium silicate at rate of 4gl^{-1} or yeast extract at 6gl^{-1} significantly surpassed compared with the other foliar treatments and control in this respect. The best results of the interaction treatments for flowering, yield and fruit parameters were recorded by the two cultivars ‘Azyad’ or ‘Revera’ combined with the foliar.

Burgos *et al.* (2015) studied the fruit growth of the summer squash cultivars: Enterprise, Pascola and Hurakan F₁. Physical (weight, diameter, and length of fruit) and chemical (pH, titratable acidity and total soluble solids). The highest number of fruits having marketing quality were shown in both ‘Pascola’ and ‘Hurakan F₁’ cultivars. Marketing quality fruits from the three cultivars showed similarities on pH (about 6.6) and decrease in titratable acidity in ‘Enterprise’ and ‘Hurakan F₁’.

Rawat *et al.* (2014) conducted an experiment involving 10 genotypes includes five parthenocarpic varieties namely ‘Hilton’, ‘Kian’, ‘Isatis’, ‘PPC-2’ and ‘PPC-3’ and five monoecious F₁ hybrids namely ‘Malini’, ‘Kamini’, ‘Sheetal’, ‘Alamgir CT-180’ and ‘NS-404’, collected from different sources. All the genotypes had a wide range of variation for most of the characters under investigation. For fruit yield per hectare in rabi season, the genotypes Kian (200.15 q), Isatis (188.78 q), and Hilton (144.30 q) were the top performers and superior over the check variety PPC-3 (122.22 q), however, Sheetal was the least yielder genotype with 82.13 q/ha fruit yield and in summer season, the genotypes Malini (590.76 q), Hilton (572.80 q), and NS-404 (523.77 q) were the top performers and superior than the check variety PPC-3 (449.02 q) however, Sheetal was the least yielder genotype with 318.19 q ha⁻¹ fruit yield. The high fruit yield recorded in the genotypes has been directly attributed to increased number of fruits per plant.

Singh *et al.* (2012a) conducted an experiment to know the performance of different improved cultivars of summer squash in naturally ventilated polyhouse under *Tarai* condition of Uttarakhand, for fruit yield and its attributes, involving 11 genotypes namely 'Champion', 'Ducato', 'Zucchini', 'Roboom Green Beauty', 'Bulam House', 'Seoul Green', 'Raboom Yellow Queen', 'Yellow Zucchini', 'Himanshu, Cheongma Zucchini' and 'Pantnagar Local' collected from local markets. The experiment was conducted at the Precision Farming Development Centre (PFDC) of the G.B. Pant University of Agriculture and Technology, Pantnagar, U. S. Nagar, Uttarakhand. Evaluation was done in Rabi season of 2009-10. The experiment was laid out in a randomized block design (RBD) using three replications, each genotype had one row, 5 m long with a plant spacing of 100 x 50 cm. Appreciable performances were recorded for seven horticultural traits. For fruit yield/ha the genotypes Gena 544 (709 q), Roboom Green Beauty (674 q), Ducato (557 q) and Seoul Green (509 q) were the top performer however, Himanshu was the least yielder genotype with 213 q/ha fruit yield. For days to first female flower anthesis Ducato was the earliest genotype with 44 days followed by Roboom Green Beauty (48 days), Seoul Green (50 days) and Gena 544 (56 days). The high fruit yield recorded in these four genotypes possess green fruit colour, has been directly attributed to increased number of fruits per plant.

Singh *et al.* (2012b) conducted an experiment during the month of April-August 2010 on evaluation of four cucumber genotypes for their earliness and fruit quality attributes under naturally ventilated polyhouse condition at KVK, Research Station, Lohaghat, Champawat, Uttarakhand. The results revealed that among the four genotypes 'PCUC-1', 'PCUC-3', 'Isatis and Kian', 'Isatis' took minimum days to first female flowering (19.2) followed by Kian, plant height was maximum in Isatis (240.4 cm) followed by PCUCP-2 (208.1 cm), earliest node at which first female flower was observed in Kian (3.2) followed by PCUCP-2 (4.0). Fruit character like fruit length was found maximum in PCUCP-

1 (13.44 cm) and fruit diameter of Kian was found to be best whereas pericarp thickness was observed maximum by PCUCP-2 (9.6 mm). The maximum fruit weight was recorded in Isatis (149.8 g) followed by Kian (137.1 g). So on the basis of above observations, it can be concluded that genotype Isatis has performed best in respect to earliness and fruit character followed by PCUCP-2.

Kumar and Verma (2012) evaluated eight cultivars of cucumber namely 'Improved Noori', 'Tasty', 'Malini', 'Ritika', 'Swarna Ageti', 'Radhika', 'Priya' and 'Swarna Purna' under protected structure at Bihar Agricultural University, Sabour, Bhagalpur replicated thrice. It was observed that the cultivar Tasty recorded maximum number of fruits per plant (12.6), average fruit weight (195.2 g fruit⁻¹) and total yield (4.92 t 500 m²) and fetches maximum return of Rs. 49200.00 from an area of 500 m² in a short span of time of three months.

Hebbar *et al.* (2012) evaluated seven hybrids variety of cucumber during rabi season in a naturally ventilated polyhouse at Indian Institute of Horticultural Research, Bangalore for three years during 2005-08. The crop was mulched and drip fertigated using water soluble fertilizers. The first harvest was made at about 40 days after sowing. Harvesting period was extended for a period of about 75 days thereafter. On an average there were 16 harvests at the interval of 5 days. Malini has recorded highest yield during the first (121.2 t ha⁻¹) and third (102.9 t ha⁻¹) year, while Rajdhani during second (134.2 t ha⁻¹) year of experimentation. Average yield over the three years was highest in Malini (117.4 t ha⁻¹) followed by US 6125 (104.0 t ha⁻¹) and Rajdhani (100.4 t ha⁻¹).

Dev (2011) experimented on 30 days old healthy seedlings of three varieties of summer squash, V1: Bulam House, V2: Cora F1 and V3: Chungma Zucchini raised in poly bags during three consecutive spring seasons from 2005 to 2007, which were transplanted on five planting times at fortnightly intervals. Significant differences were recorded for all the traits studied during all the three

years. The maximum yield (766.2 q/ha), average fruit weight/size (1320.4 g) and number of fruits per plant (22.6) were produced by planting the variety Cora F1 on February 16. The delay in planting reduced the yield, its attributes and also days to maturity. It is concluded that summer squash variety Cora F1 planted in mid February gave the highest yield followed by Chungma Zucchini under the low hill conditions.

Bisht *et al.* (2011) conducted two independent trials during winter season at Vegetable Research Centre of the G.B. Pant University of Agriculture and Technology. In the first trial, conducted during first two years, four cucumber varieties were tested for their off-season performance in a naturally ventilated polyhouse. In the first year, the varieties Poinsett, Pant Sankar Kheera-1, Pant Kheera-1, and Phule Prachi were included, while during second year, Phule Prachi was replaced by US-6125 due to non-availability of seeds. The second trial was conducted during third year in which eleven open-pollinated varieties/hybrids were tested including Poinsett, Pant Sankar Kheera-1, Pant Kheera-1, US-6125, Rani, Noori, Tripti, Phule Shubhangi, Sheetal, Kalyanpur Green and Ragini. Cucumber seeds were sown on 17-10-02, 11-11-03 and 01-11-04 during first, second and third year, respectively. The spacing was maintained at 80 cm $\times$ 50 cm having 8 plants in each variety. Five replications were kept in first trial; while in second trial three replications were adopted in a randomized block design. The crop duration was six months in each year. The observations were recorded on growth, maturity and yield characters. Among the eleven varieties, Poinsett ranked first in terms of number of fruits per plant which was large 32.80 closely followed by Phule Shubhangi. The variety Poinsett recorded significantly larger number of fruits per plant compared to all other varieties. The mean fruit yield per plant (5.27 kg) and per ha (1463.33 q) were found maximum in Poinsett. This may possibly be due to the better adaptability of this variety to the polyhouse condition, which resulted in comparatively better

vine length, more number of primary branches and largest number of fruits per plants.

Sharma *et al.* (2010) conducted an experiment in naturally ventilated polyhouse in rainy season during 2007-08 and 2008-09 at Rajasthan College of Agriculture, Udaipur to identify the most suitable cultivar, plant geometry and method of fertilizer application in cucumber. The results revealed that cultivar Hilton was significantly superior to enhance vine length (3.29 m), leaf area (500.99 cm²), days to first harvest (44.40 days), fruit set (51.04%), number of fruits per vine (30.89), average weight of fruit (105.28 g), fruit length (18.22 cm) and fruit width (3.62 cm) which ultimately gave maximum yield per vine (3.49 kg) during rainy season.

Ahmed *et al.* (2004) studied the performance of different exotic and indigenous cultivars of cucumber (*Cucumis sativus* L.) namely; Market More, Poinsett-76, Electron, Konkurent, Yadenctva and Punjab Local were evaluated for their growth and yield characteristics under agro-climatic conditions of Rawalakot (Azad Jammu and Kashmir). The cultivar Market More produced maximum number of fruits per plant with greater fruit length, followed by the cultivar Poinsett-76 and these two cultivars stood statistically at par. Maximum fruit yield/plant and per hectare was obtained from the cultivar Market More followed by the cultivar Poinsett-76, which could be attributed to more number of fruits per plant and greater fruit length.

2.2 Effect of growth regulators

El-Salehein (2019) carried out a study in summer seasons of 2017 and 2018 at a private farm in Sheiba Region, Zagazig City. The study was aimed to study the effect of spraying ethrel at the appropriate plant leaves stage development (two immature leaves as well as one, two and three true leaves stage) on plant growth, chemical composition, flowering, yield and fruit quality of squash CV.

Eskandarany. The results indicate that, spraying squash plants with ethrel (250 ppm) once at the two immature leaves, significantly increased vegetative growth, leaves nitrogen content, number of female flowers, yield, as well as the physical and chemical quality of fruits. Moreover, the highest values of total chlorophyll, phosphorus and potassium percentage of leaves were recorded by spraying ethrel at the age of two true leaves.

Arabsalmani and Rashidi (2017) carried out a field experiment to investigate the effect of Ethephon levels at different growth stages of plant on male flowers in cantaloupe (*Cucumis melo* L.) during 2013 and 2014 growing seasons. The tests were done as a split plot experiment in a randomized complete block design with three replications to randomize the different growth stages and Ethephon levels in the main and sub-plot, respectively. The experiments comprised of three growth stages (3 and 6-leaf stages and early reproductive growth) and four Ethephon levels (0, 100, 200 and 300 ppm of effective substance). Traits measured in the experiment were the appearance time of female flowers (ATFF), number of male flowers (NMF) and number of female flowers (NFF) recorded 7 and 14-days after spraying Ethephon and yield. Statistical results of study indicated that plant response to increasing levels of Ethephon was different among different growth stage. Moreover, increasing Ethephon level increased the appearance time of flowers (male and female). Also, the highest yield (25834 kg ha⁻¹) was obtained with consumption of 100 ppm Ethephon 1 in trifoliolate plants. A high level of Ethephon (200 ppm and more) at all growth stages, especially at the reproductive growth stage was associated with significant reductions of yield.

Sakthinathan *et al.* (2017) carried out with the application of growth regulator ethrel (250 ppm) on five different cultivars (Pumpkin big, Yellow big, Pennadam local and Melur local) of pumpkin with two stage of application (3 -4 leaf stage and 15 days after first spray) along with control. The result of the study revealed

that spraying of ethrel @ 250 ppm at 3-4 leaf stage and 15 days after the first spray highly influences on sex modification in yellow big cultivar than other cultivars. Spraying of ethrel (250 ppm) significantly enhanced the growth parameters and yield by reducing the staminate / male flowers and increasing the female/pistillate flowers.

Chaudhary *et al.* (2017) carried out this investigation with ten treatments *viz.*, T₁ (Control), T₂ (GA₃ 10 ppm), T₃ (GA₃ 20 ppm), T₄ (GA₃ 30 ppm), T₅ (Ethrel 50 ppm), T₆ (Ethrel 100 ppm), T₇ (Ethrel 150 ppm), T₈ (Ethrel 25 ppm), T₉ (NAA 50 ppm) and T₁₀ (NAA 100 ppm). The results revealed that, the maximum length of the main vine at 60 and 90 DAS (225.07 and 268.21 cm), respectively, and number of leaves per plant at 60 and 90 days after sowing (205.78 and 332.17) and produced the maximum number of male flower (228.56) were recorded with treatment (T₄) GA₃ 30 ppm. Treatment (T₇) Ethrel 150 ppm proved to be most effective for produced the minimum number of sub-vine at 60 and 90 DAS (7.78 and 9.22), lower node number at which first female flower appears (5.60), lower node number per plant at main vine (24.11), lower internodal length (9.56 cm), maximum total leaf area per plant (92.39 cm²), number of female flower (45.78) and fruit set percent (66.18), numbers of fruits (28.78), fruit weight (68.00 g/fruit), fruit yield per plant (2.59 kg), fruit yield per plot (18.14 kg) and higher fruit yield per hectare (129.33 q/ha). The lowered sex ratio was recorded in treatment (T₆) Ethrel 100 ppm i.e. (1: 4.06).

Chormule and Patel (2017) conducted investigation entitled “Effect of spacing and plant growth regulators on plant growth parameters, seed yield and its attributes of okra variety for two consecutive seasons. Seeds were treated with aqueous solution of growth regulators *viz.*, GA₃, IBA and NAA, each at 50, 100 and 150 ppm concentrations and without growth regulators (water soaking). The growth regulators were applied as seed soaking treatment for 8 hours. Treated seeds were grown with three plant spacing (S₃ : 45 cm × 30 cm, S₂ : 60 cm × 30

cm and S₃ : 60 cm × 45 cm) during Kharif 2015 and 2016. Interactions effects of spacing and seed treatments (S×T) with growth regulators were found significant for field emergence, a number of branches per plant, fruit length and fruit thickness during Kharif 2015; for fruit length and fruit thickness during Kharif 2016; and for field emergence in pooled over years. Wider spacing of 60 cm × 45 cm (S₃) and seeds treated with GA₃ 150 ppm (T₃) recorded significantly the maximum values for growth parameters *viz.*, plant height, stem diameter and number of branches per plant: seed yield and yield attributes *viz.*, seed yield per plant, number of fruits per plant, fruit thickness and number of seeds per fruit. A combination of wider plant spacing 60 cm × 45 cm and seed treatment of GA₃ @ 150 ppm before sowing (S₃T₃) was found best suited combination, as it has good field emergence and produced significantly and/or comparatively the maximum plant height, stem diameter, number of branches per plant, number of fruits per plant, fruit length, fruit thickness, number of seeds per fruit and seed yield per plant.

Shafeek *et al.* (2016) conducted a study to survey the reply of squash plants (*Cucurbita pepo* L.) to foliar exercise of several bio-regulators (GA₃) at several concentrations (15, 30, 45 and 60 mg/L) or Ethereal at the levels of (150, 200 and 250 mg/L) and foliar spraying with water (control) to the effect of impact plant growth sex expression, proportion of fruit set, fruits yield and nutritional supplement of squash fruits c.v. Eskandarani. The concise outcome gained from this field research that, mounting the concentrations of growth regulators (GA₃ or Ethereal) fulfilled tallest plant, highest number of leaves and branches, heaviest fresh and dry weight of leaves, branches, leaf area /plant and fruit set percentage as well as total yield and highest values of the percentage of N, protein, dry matter, TSS and vitamin C (mg/100g F.W.) in squash fruit tissues.

Dalai *et al.* (2015) conducted an experiment was conducted to assess the effect of various doses of GA₃, NAA, and their combined dose. Total of eight

treatments were tried in RBD with three replications. Out of these, a dose of GA₃ 20 ppm + NAA 100 ppm was found significantly superior in terms of growth parameters i.e. vine length plant⁻¹ (cm), number of primary branches plant⁻¹, number of leaves plant⁻¹, as compared to control and other applied treatment. Similarly, a positive effect was also reported in various flowering, yield and yield attributing characters with GA₃ 20 + NAA 100 ppm. In the context of yield, a dose of GA₃ 20 + NAA 100 ppm was produced the highest yield of cucumber as compared to control and other treatments during experimentation.

Tsiakaras *et al.* (2014) carried out an experiment to find out the effect of both nitrogen application rate and gibberellic acid (GA₃) on yield and earliness of production and marketability (plant height and leaf color) of lettuce. During cultivation, four nitrogen rates (0, 150, 300 and 450 mg L⁻¹ of N) and two foliar sprays of two concentrations of GA₃ (0 and 50 mg L⁻¹ for the first and second sowing and 0 and 25 mg L⁻¹ for the third sowing) were applied. Results revealed that total fresh and dry weight significantly decreased and increased, respectively, by GA₃ application, especially in the second sowing date, whereas high nitrogen rates (300 and 450 mg L⁻¹) resulted in higher fresh weight (by 11.2%) and lower dry weight (by 7.5%) respectively. Plant height was significantly increased by GA₃ application, except for cv. 'Adranita' in the third sowing date, whereas nitrogen application did not affect plant height for all the cultivars studied. The application of GA₃ and high nitrogen rates resulted in an increase in the total number of leaves per plant and a decrease of chlorophyll content of leaves during the first sowing date and third sowing date.

Mahmoody *et al.* (2014) reported that exogenous GA₃ on culture medium was used to increase the height of *Dyckia aritima* shoots to facilitate *In vitro* manipulation. Grapevine fruits (Thompson seedless) treated with GA₃ had increased its size and production. Results revealed that foliar application of and GA₃ nutrients had improved the productivity and quality of lily cut flowers.

Stimulation of the enzyme protein synthesis by GA₃ stimulates the overall protein synthesis.

Kumar *et al.* (2014) determined the effects of Gibberellic acid (GA₃) on the growth, fruit yield and quality of tomato. The experiment consisted of one tomato variety Golden, and six treatments with five levels of gibberellic acid (GA₃-10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm). The highest plant height, number of leaves, number of fruits, fresh fruit weight, ascorbic acid and total soluble solids (TSS) was found from GA₃ 350 ppm.

Ayyub *et al.* (2013) assessed the effectiveness of GA₃ as a foliar application for enhanced vegetative and reproductive growths of okra. First foliar application of GA₃ (100 mg Kg⁻¹) was performed after 3 weeks from sowing while the next three applications with regular interval of one week. Their experiment results revealed that the increase in a number of foliar application of GA₃ substantially improved the vegetative as well as reproductive growth of okra comparing to control plants. It was found that application at different growth stages of okra predominantly boosted the stem elongation, number of leaves per plant, number of pods per plant, number of seeds per pod, seed weight and seed yield. Therefore it can be concluded that the foliar application of GA₃ may be an effective strategy for maximizing the growth and yield of okra.

Ezzo *et al.* (2012) showed that complete replacement of mineral nitrogen fertilization by chicken manure treatment was associated with slow plant growth, but early flowering and then lower fruit production. Whereas, additional treatments, i.e., soaking squash seeds in garlic extract, spraying squash seedlings with ethrel and both of them stimulate plant growth, increased female flowers ratio, and then improve fruit production and quality. Soaking seed in garlic extract treatment gave better result in all investigated item than spraying the seedlings with ethrel. In conclusion, the best results among the four organic

fertilization treatments were obtained when squash seeds were soaked in garlic extract before sowing together with spraying the seedlings with ethep. In addition, there were no significant differences between this treatment and 100 % mineral nitrogen fertilization treatment regarding to plant growth, mean fruit weight and early yield parameters. But it comes in the second significant grade as for total yield parameters after 100 % mineral nitrogen fertilization treatment.

Jadon *et al.* (2012) conducted a field experiment to study the effect of gibberellic acid, IBA and NAA as a foliar spray of cauliflower. Among growth regulators, GA₃ was most promising in effect followed by NAA and IBA. The growth regulator GA₃ @ 150 ppm showed significantly higher performance over the remaining treatment in all the growth characters *viz.*, plant height, etc. Growth regulator GA₃ @ 150 ppm performed significantly better than the other treatments regarding the yield and yield attribute characters. Growth regulator GA₃ @ 15 ppm with recommended fertilizer dose of NPK gave the highest additional net profit over control followed by GA₃ @ 100 ppm.

Kumar and Wehner (2012) conducted to determine whether the rate of natural out crossing could be increased using growth regulators, plot size management, and node of fruit position for seed harvest. Results showed that node of harvest had no effect on outcrossing rate. However, growth regulators and plot size had a significant effect. Treated small plots, treated hills, and untreated hills had high out crossing rates (54%) relative to untreated plots (30%). Therefore, if families are to be intercrossed in isolation blocks, they should be treated with growth regulators for maximum out crossing.

Taha (2012) showed that GA₃ treatments significantly increased leaf length, while, CCC and Alar treatments significantly decreased the leaf length compared to treatment. GA₃ treatments shortened significantly the time taken from planting to flowering, while CCC and Alar treatments significantly delayed the flowering

date compared to control. Also, the flowering stalk length was increased by application of GA₃ at the three used concentrations, while, CCC and Alar at the same concentrations led to a decrease in the flowering stalk length. The positive or negative effects of GA₃ or CCC and Alar were gradually increased by increasing their concentrations. All treatments of GA₃, CCC and Alar led to increased flowering stalk diameter, fresh and dry weights of the flowering stalk and fresh weight of inflorescence/plant compared to control. The best results were obtained by using of high concentration of GA₃, CCC, and Alar. All GA₃, CCC, and Alar treatments had a stimulatory effect on the formation of new bulbs and bulblets compared to the treatment. The highest of fresh weight of new bulbs and bulblets/plant and the highest number of bulblets/plant were obtained by the application of GA₃ at 750 ppm, CCC at 1000 ppm and Alar at 500 ppm.

Thappa *et al.* (2011) examined of two of the growth regulators, maleic hydrazide and ethephon, were each applied at two different concentrations of 100 and 200 ppm and the third, naphthalene acetic acid, was applied at 50 and 100 ppm, and some combined applications of growth regulators were also tested. The experiment comprised 15 treatments and was laid out in a randomized block design with three replications. The results revealed that the influence of the plant growth regulators was variable on the morphological traits of cucumber but the floral and yield traits were significantly affected by a combined application of 100 ppm maleic hydrazide and 100 ppm ethephon. This treatment induced early development, maximized the sex ratio with regard to yield and was comparatively helpful in reducing plant expansion. This treatment also produced the best economic results for the production of cucumber.

Roy and Nasiruddin (2011) conducted a research work to study the Effect of ethrel on growth and yield of cabbage. Single factor experiment consisted of four concentrations of GA₃, viz., 0, 25, 50 and 75 ppm. Significantly the minimum number of days to head formation (43.54 days) and maturity (69.95 days) was

recorded with 50 ppm GA₃ and 50 ppm GA₃ gave the highest diameter (23.81 cm) of cabbage head while the lowest diameter (17.89 cm) of cabbage head was found in control (0 ppm GA₃) treatment. The application of different concentrations of GA₃ as influenced independently on the growth and yield of cabbage. Significantly the highest yield (45.22 kg/plot and 104.66 t/ha) was found from 50 ppm GA₃.

Emongor and Ndambole (2011) examined the effects of GA₃ on the growth, development and seed yield of cowpeas (*Vigna unguiculata*). Three field trials were carried out to evaluate the exogenous application of GA₃, 7 days after emergence at 0, 100, 200 or 300 mg L⁻¹ significantly increased cowpea plant height, first node height, leaf area and leaf number plant⁻¹, nodulation, plant dry matter, pod length, pod number plant⁻¹, seed number pod⁻¹, 100-seed weight, harvest index, and seed yield.

Akter *et al.* (2007) revealed that GA₃ at 50 ppm significantly increased plant height, number of fertile siliqua/plant, number of flowers/plant, setting of siliqua/plant (%), dry matter yield, number of seeds/siliqua, and harvest index, while the number of flowers/plant was significantly increased with the application of 75 ppm GA₃. The highest seed yield/plant was recorded from the application of 50 ppm GA₃ at optimum harvest date. The seed yield/plant was positively correlated with plant height, number of seeds/siliqua, number of fertile siliqua/plant and % of setting siliqua/plant.

Jasim and Fayadh (2007) conducted to find out the effect of garlic extract at (1:0.5) and (1:1) (wt: volume) concentration and Liquorous extract at 1.25 and 2.50 mg/ L and growth regulator IAA at 25, 50 and 75 mg/ L and ethephon at 100, 200, 300 mg/ L on endogenous hormones (auxins and gibberellins) and carbohydrates at three growth stage of snak cucumber and cucumber which were; third to fourth true leaf stage, male flower appearance stage and female

appearance stage . Gibberellins contents decreased significantly by Liquorous at 2.50 gm/L for both plants in the second season only whereas, auxins contents increased by treatment of garlic (1:1) and Liquorous (2.5 gm/L) in cucumber for both seasons. Carbohydrates contents decreased at IAA (25 and 50 mg/L) for both season and increased in second season by ethephon in snake cucumber and by IAA (75 mg/L) in the first season in cucumber. Male flowers appearance stage gave highest gibberellins contents compare to other stages. Female flowers appearance stage gave highest auxins and carbohydrates contents compare to other stages. Ethephon at 300 mg/L treatment at female flower appearance stage gave the lowest gibberellins and highest auxins and carbohydrates for both plant and seasons.

Bora and Sarma (2006) carried out a study on the effect of Gibberellic acid (GA_3) and Cycocel on growth, yield and protein content of pea (*cv.* Aparna and Azad-P-1). GA_3 irrespective of concentrations was most effective in promoting shoot growth while cycocel at all concentrations tried reduced shoot growth. The number of branches per plant was increased with both the hormones. In both, the varieties chlorophyll contents were decreased by higher concentrations of GA_3 while cycocel increased it. Both the hormones significantly affected the yield characteristics. GA_3 at 250 pg mL^{-1} produced a maximum number of pods per plant, seed yield, seed index and protein content in seeds in both the varieties. Their study clearly showed that the judicious application of GA_3 and cycocel can increase yield and protein content in seeds of a pea.

Hossain (2004) conducted an experiment to study the effect of “Crops care” (Napthalene Acetic Acid, NAA 4.5%) and “Ripon-15” (15% Ethephon) on the flower initiation, fruit set and yield of cucumber (Barishal HYV) and bitter gourd (Tia HYV). “Crops care” and “Ripen-15” showed positive effects on different yield attributing characters of cucumber and bitter gourd treated plants compared to the control. Early female flowers (6 to 7 days) and early fruit maturation (5

days) were found in both cucumber and bitter gourd plants treated with “Crops care” (0.5 ml) and “Ripen-15” (3 ml) compared to control. “Crops care” (0.4 ml) gave about (30%) more female flower in cucumber and (32%) more in bitter gourd. About (45%) more female flower was recorded in cucumber from the plants treated with 2.0 ml of “Ripen-15” and (56%) more female flower was recorded in bitter gourd treated with 2.5 ml of “Ripen-15”. About 7 ton more yield was found from 0.4 ml of “Crops care” both in cucumber and bitter gourd. 2.0 ml of “Ripen- 15” gave 7.6 t ha⁻¹ and 7.85 t ha⁻¹ more yield in cucumber and bitter gourd respectively over the control.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental Site

The research was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 from October 2018 to March 2019. The experimental field was located at 90° 22' E longitudes and 23° 41' N latitude at an altitude of 8.2 meters above the sea level. The land was in the Agro-Ecological Zone of Madhupur tract (AEZ No. 28). It was deep red brown terrace soil and belonged to “Nodda” cultivated series. The soil was sandy loam in texture having pH 5.47 to 5.63. The physical and chemical characteristics of the soil have been presented in the appendix II.

3.2 Climate

The experimental area was under the sub-tropical monsoon climate, which is characterized by scanty rainfall during Rabi season (October to March). The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experimental area during the study period were collected from Bangladesh Meteorological Department (climate division) and have been presented in the Appendix III.

3.3 Planting materials

Seeds of squash (GS-1, Cherub and Cheonlima) were collected from the Siddik Bazar, Dhaka and used in the experiment.

3.4 Experimental factors and treatment combinations

Experiment was consisted of two factors.

Factor A: Varieties

There were three varieties. These are-

1. V₁: GS-1

2. V₂: Cherub
3. V₃: Cheonlima

Factor B: Ethrel

Three levels of ethrel were used in the experiment. The treatments were-

1. E₀: 0 ppm (control)
2. E₁: 250 ppm
3. E₂: 500 ppm

Total 9 treatment combinations were as follows:

V ₁ E ₀	V ₂ E ₀	V ₃ E ₀
V ₁ E ₁	V ₂ E ₁	V ₃ E ₁
V ₁ E ₂	V ₂ E ₂	V ₃ E ₂

3.5 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The experiment was divided into three blocks and each consisted of 9 plots. Each unit plot was 1.6 x 1.6 m² in size. Altogether there were 27 unit plots in the experiment and required 147.42 m² land. Both block to block and plot-to-plot distances were 0.5 m. The treatments were randomly assigned to each of the block. Each unit plot had 4 pits and each pit contained 2 plants.

3.5.1 Preparation of the spray solution

1000 ppm solution of ethrel (40% a. i.) was prepared by mixing 1 ml ethrel (commercial formulation) to 400 ml of water. The solution was prepared fresh and dilutions of the required concentrations (250 and 500 ppm) were made. 1st ethrel application was done in 3 leaf stage of plant in 19 Nov. 2nd ethrel application was done in 5 leaf stage of plant in 30 Nov. In case of 250 ppm of ethrel application, 125 ppm was sprayed in 3 leaf stage and 125 ppm was sprayed in 5 leaf stage. Same procedure was followed in case of 500 ppm application.

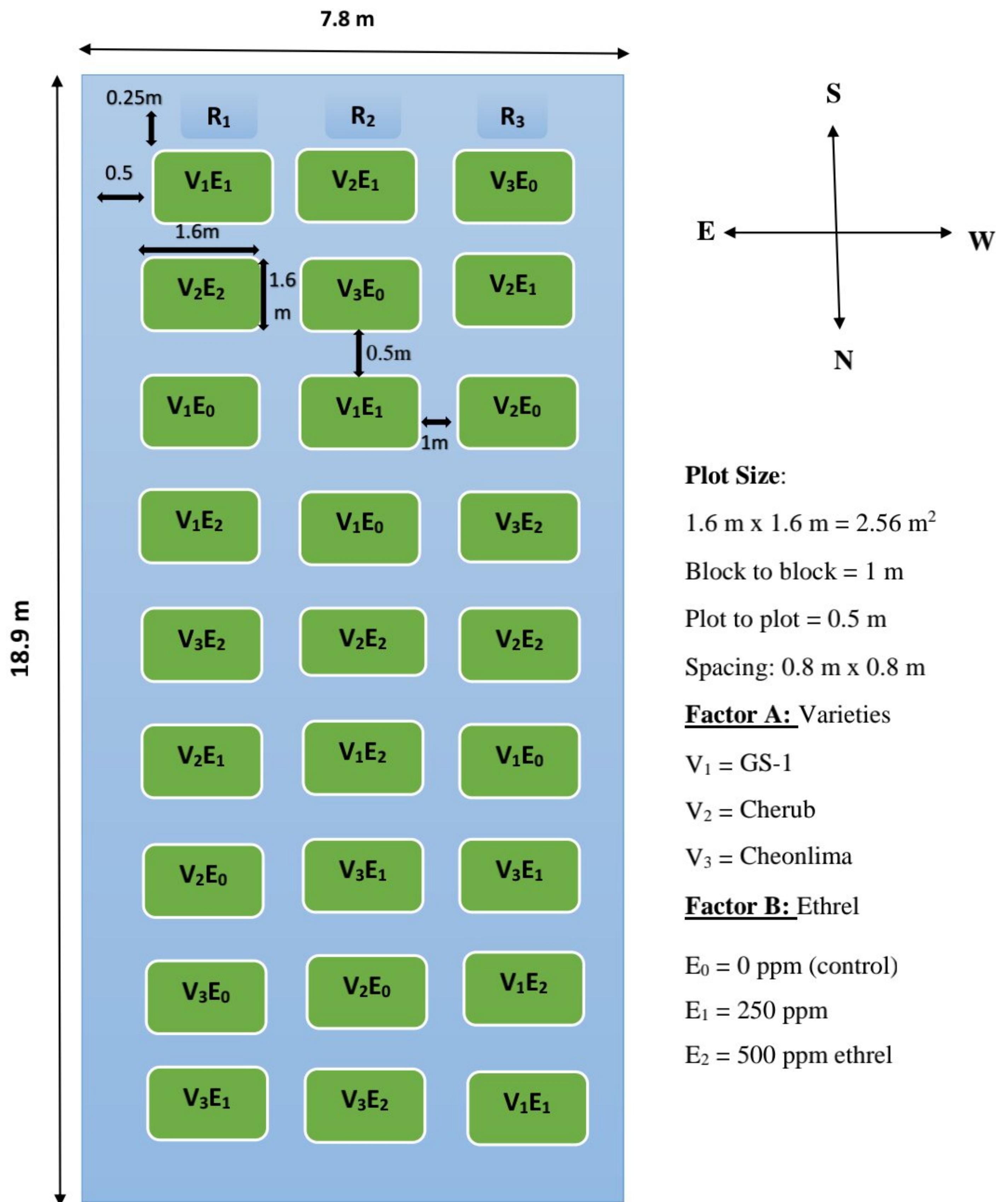


Fig. 1. Layout of the experiment at field

3.5.2 Seedbed preparation and raising of seedlings

The land selected for the nursery bed was well drained and were 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 and the soil was mixed with well rotten cowdung at the rate of 5 kg/bed. Seedbed size was 3m × 1m raised above the ground level. The bed was prepared for raising the seedlings. Thirty (30) grams of seeds were sown in the seedbed on 31 October 2018. After sowing, the seeds were covered with light soil. Complete germination of the seeds took place with 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 seedbed.

3.6 Preparation of the research field

The plot selected for the experiment was opened in the 31 October 2018 with a power tiller and was exposed to the sun for a few days, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting. The land operation was completed on 12 November 2018. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.7 Fertilizers and manure application

The N, P, K, and S fertilizer were applied according to Krishi Projukti Hat Boi (BARI, 2015) through urea, Triple superphosphate (TSP), MoP and Gypsum, respectively. Cowdung also used as organic manure. Nitrogen (N) was applied through urea. Nutrient doses used through fertilizers under the present study are presented as follows:

Nutrients	Manures/fertilizers	Doses ha ⁻¹
-	Cowdung	10 ton
N	Urea	170 kg
P	TSP	170 kg
K	MoP	150 Kg
S	Gypsum	100 kg

One third (1/3) of the whole amount of Urea and the full amount of TSP, MOP, and Gypsum were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments- at 25 and 35 days after transplanting (DAT), respectively.

3.7.1 Transplanting of seedlings

Healthy and uniform sized 13 days old seedlings were taken separately from the seedbed and were transplanted in the experimental field on 12 November 2018. Plant spacing 80 cm × 80 cm was maintained for transplanting. The seedbed was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by a piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

3.8 Intercultural operations

Various intercultural operations were done when required.

3.8.1 Weeding and mulching

Manual weeding was done as and when necessary to keep the plots free from weeds. The soil was mulched by breaking the crust of the soil for easy aeration and to conserve soil moisture as and when needed. Mulching also helped to disturb the emergence of weeds. These two operations were done carefully without hampering the luxurious crop health.

3.8.2 Irrigation

Immediately after transplanting light irrigation was given around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was done whenever it was necessary.

3.8.3 Pest control

There was a plan to protect the plant from the attack of insects-pests squash vine borer and squash bugs by spraying of pesticides. For controlling squash bugs, two applications of pyrethroid insecticide were effective. Squash vine borer insect was controlled by applying carbaryl for 2 times.

3.9 Harvesting

Harvesting should be done at the right stage. Squashes are harvested when immature, and used as a fresh vegetable stewed, boiled or fried. They develop very rapidly after their flowers have opened, and must be harvested before the rind begins to harden. When gathering squashes or pumpkins for storage, careful handling is needed to avoid bruising, as damaged fruit soon rots.

3.10 Collection of data

Data were recorded on different morphological, yield components and yield from ten randomly selected sample plants.

3.11 Procedure of recording data

3.11.1 Plant height

The plant height was recorded in centimeter (cm) at different days after transplanting of crop duration with a meter scale. Data were recorded from each plot. The length was measured from the ground level to the top of the stem. Data was taken at 15, 30 and 45 days after transplanting (DAT) and at harvest.

3.11.2 Number of leaves plant⁻¹

Number of leaves plant⁻¹ was counted at different days after sowing of crop duration. Leaves number plant⁻¹ was recorded from each plot and mean was calculated. Data was taken at 15, 30 and 45 days after transplanting (DAT) and at harvest.

3.11.3 Leaf length

Leaf length was measured by using a meter scale. The measurement was taken from base of leaf to tip of the petiole. Average length of leaves was taken from five random selected leaves from each plant from each plot. Leaf length of plant was measured at 15 DAT, 30 DAT, 45 DAT and at harvest and the average was calculated.

3.11.4 Leaf breadth

Leaf breadth was measured by using a meter scale. Average breadth of leaves was taken from five random selected leaves from each plant from each plot. Leaf breadth of plant was measured at 15 DAT, 30 DAT, 45 DAT and at harvest and the average was calculated.

3.11.5 Stem diameter

The diameter of stem base in centimeter (cm) was recorded from each plant of each plot at different days after transplanting at 15DAT, 30 DAT, 45 DAT and at harvest at the base portion of the plant with slide calipers. The average value is termed as stem diameter.

3.11.6 Days for the 1st male and the 1st female flowering

Days required for 1st male and female flowering was counted from every four plants per plot.

3.11.7 Days for the 50% male and female flowering

Days required for 50% male and female flowering was counted from every four plants per plot.

3.11.8 Number of female flowers plant⁻¹

Total number female flowers was counted from four plant per plot. Female flowers were selected based on the presence of initial oval shape fruit like structure at the base of flower.

3.11.9 Number of male flowers plant⁻¹

Total number of male flowers was counted from four plant per plot. Male flower selected based on the absence of initial oval shape fruit like structure at the base of flower.

3.11.10 Number of fruits plant⁻¹

The number of fruits in every plant of squash was counted at every harvest and thus the total number of fruits per plant was recorded and average number of fruits was also recorded.

3.11.11 Fruit length and breadth

Length of fruits per plant was measured after each harvest and then the average was taken. Breadth of the same fruits as harvested was measured and the average was calculated.

3.11.12 Individual fruit weight

From the first harvest to last harvest total fruit number and fruit weight was counted from each plant of each plot to determine single fruit weight. Single fruit weight was calculated from total fruit weight dividing by a total number of fruits.

3.11.13 Percent fruit dry matter

Fresh 100 g sample fruit from each plot were taken and placed in an oven maintained at 70⁰ C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the sample was taken and recorded as percent (%) dry matter.

3.11.14 Fruit weight plant⁻¹

Total fruit weight was measured from each plant of each plot from 1st to last harvest and the average weight was calculated as a fruit yield per plant.

3.11.15 Fruit yield ha⁻¹

After collection of fruit per plot, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000 \text{ m}^2}{\text{Plot size (m}^2\text{)} \times 1000 \text{ kg}}$$

3.12 Statistical analyses

The recorded data on different parameters were statistically analyzed using Statix-10 software to find out the significance of variation resulting from the

experimental treatments. The mean for the treatments was calculated and analysis of variance for each of the characters was performed by F (variance ratio) test. The differences between the treatment means were evaluated by LSD test at 5% probability.

CHAPTER IV

RESULTS AND DISCUSSIONS

The present experiment was conducted to determine the effect of variety and different doses of ethrel on growth and yield of squash. The analyses of variance (ANOVA) of the data on different components are given in Appendix IV to XI. The results have been presented, discussed, and possible interpretations have been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Significant variation was observed for plant height at different growth stages influenced by the simple effect of different varieties (Appendix IV). The highest plant height (9.59, 23.10, 49.19 and 55.53 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the variety V₁ (GS-1) where the lowest plant height (7.11, 17.73, 38.34 and 42.73 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the variety V₂ (Cherub) at all growth stages (Fig. 2).

The plant height was significantly influenced by the simple effect of different levels of ethrel application at different growth stages (Appendix IV). The highest plant heights (9.82, 24.02, 51.21 and 56.97 cm at 15 , 30 , 45 DAT and at harvest, respectively) were found from E₁ (250 ppm ethrel) (Fig. 3). The lowest plant height (7.08, 17.31, 37.38 and 42.17 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from E₂ (500 ppm ethrel) (Fig. 3). Thus, during the initial phase of vine growth, effect of ethrel was anticipated since it releases ethylene and the inhibitory effect of ethylene on shoot growth have been attributed to the reduction of auxin levels (Leiberman and Knecht, 1977) possibly via ethylene induced acceleration of auxin metabolism (Riov *et al.*, 1982).

Ethylene also inhibits IAA transport in plant systems, where ethylene inhibits elongation (Morgan and Gausman, 1966 and Malloch and Osborne, 1976). This increment in these characters of fruits may be refer to the genetic variation between the genotypes. In this regard, Esho and Saeed (2016) and Hassan *et al.* (2016) indicated that the variability among summer squash varieties attributed to its genetic make-up. The varietal differences in this connection were also reported by Aly (2002) and Yoldas (2014) who working on summer squash, and Ene *et al.* (2016) on cucumber. They demonstrated that fruit physical characters were significantly affected by the variety.

The recorded data on plant height at different growth stages were significantly influenced by the interaction effect of variety and ethrel (Appendix IV). The result revealed that the highest plants (11.47, 27.07, 56.98 and 63.77 cm at 15 , 30 , 45 DAT and at harvest, respectively) were noted from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) (Table 1). The lowest plant heights (5.76, 14.24, 31.30 and 34.62 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were experienced from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

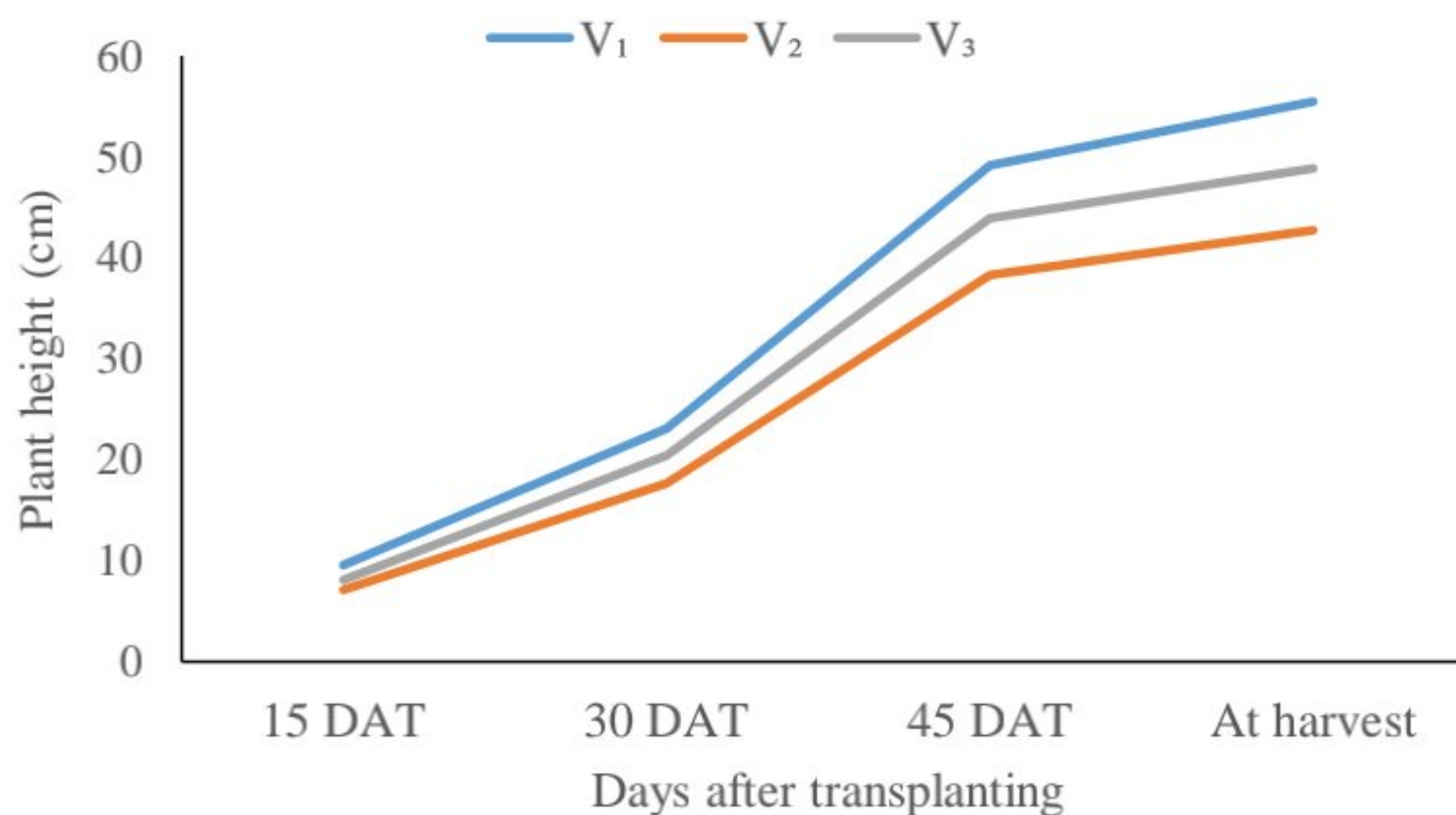


Fig. 2. Effects of variety on the plant height (cm) of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

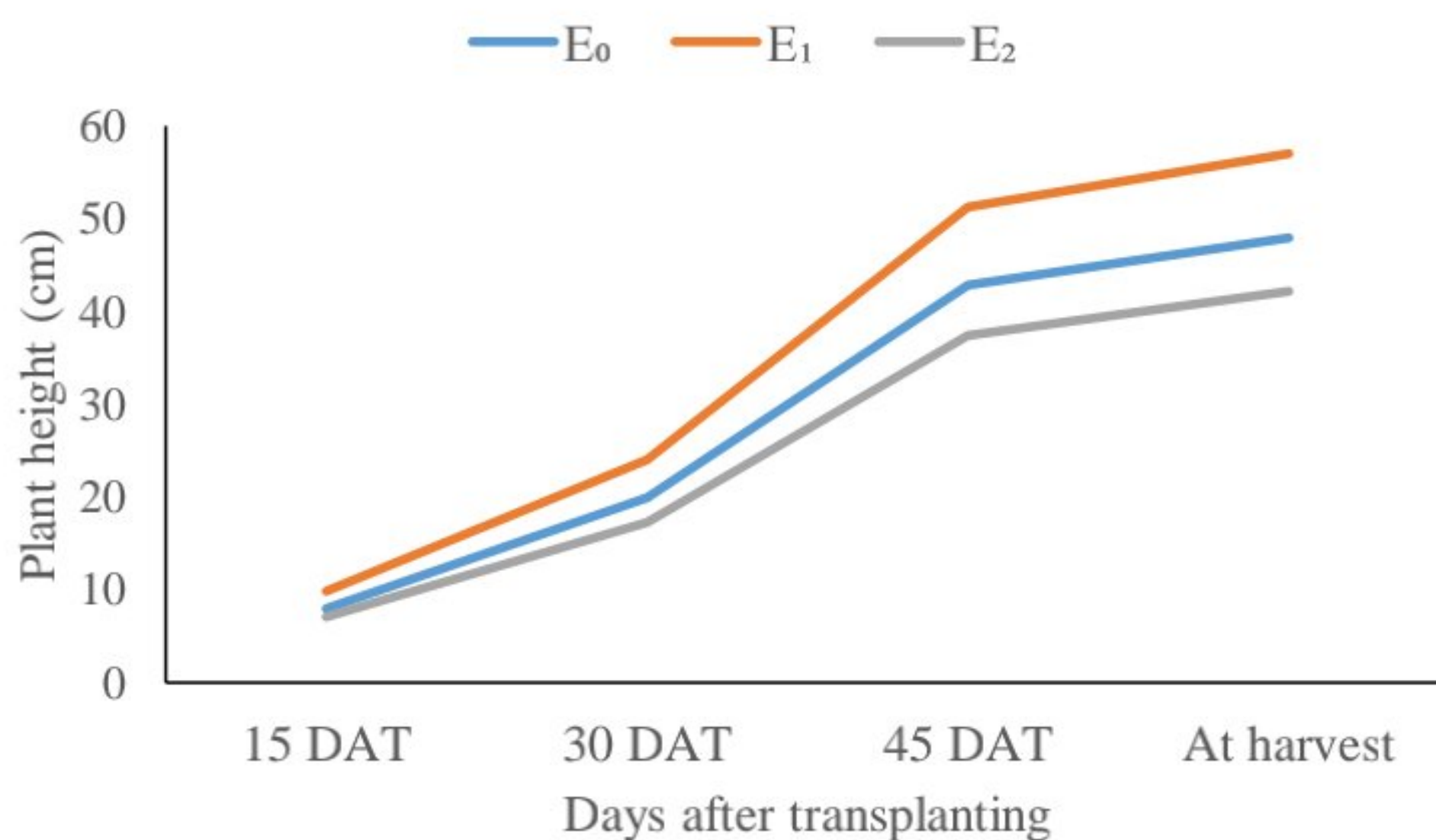


Fig. 3. Effects of ethrel on the plant height (cm) of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 1. Interaction effects of variety and ethrel on plant height of squash at different days after transplanting (DAT)

Treatment combination	Plant height (cm) at			
	15 DAT	30 DAT	45 DAT	Harvest
V ₁ E ₀	9.11 b	22.79 b	48.99 b	54.84 b
V ₁ E ₁	11.47 a	27.07 a	56.98 a	63.77 a
V ₁ E ₂	8.18 c	19.44d e	41.61 d	47.97 c
V ₂ E ₀	6.74 d	16.86 e	36.25 e	40.57 d
V ₂ E ₁	8.84 b	22.10 bc	47.46 bc	52.98 b
V ₂ E ₂	5.76 e	14.24 f	31.30 f	34.62 e
V ₃ E ₀	8.06 c	20.15 cd	43.33 cd	48.49 c
V ₃ E ₁	9.15 b	22.89 b	49.20 b	54.16 b
V ₃ E ₂	7.29 d	18.25d e	39.23 de	43.91 c
CV	4.46	7.33	6.23	4.27
LSD _(0.05)	0.639	2.589	4.72	3.621

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.1.2 Number of leaves plant⁻¹

There was a significant variation on number of leaves plant⁻¹ influenced by different varieties at different growth stages (Appendix V). The highest number of leaves plant⁻¹ (7.99, 15.36, 21.51 and 23.97 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V₁ (GS-1) (Fig. 4). The lowest number of leaves plant⁻¹ (6.51, 12.58, 17.46 and 19.45 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V₂ (Cherub) which was also significantly different from all other treatments (Fig. 4).

Significant variation was observed on a number of leaves plant⁻¹ at different growth stages influenced by different levels of ethrel (Appendix V). The highest number of leaves plant⁻¹ (8.15, 15.79, 21.95 and 24.45 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E₁ (250 ppm ethrel) (Fig. 5)). The lowest number of leaves plant⁻¹ (6.32, 12.12, 16.97 and 18.91 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E₂ (500 ppm ethrel) (Fig. 5). Tsiakaras *et al.* (2014) also found a similar result with the present study.

The recorded data on a number of leaves plant⁻¹ at different growth stages were significantly influenced by the interaction effect of variety and ethrel except 15 DAT (Appendix V). The highest number of leaves plant⁻¹ (9.11, 17.52, 24.53 and 27.33 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which were significantly different from all other treatment combinations (Table 2). The lowest number of leaves plant⁻¹ (5.67, 10.79, 15.10 and 16.82 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) (Table 2).

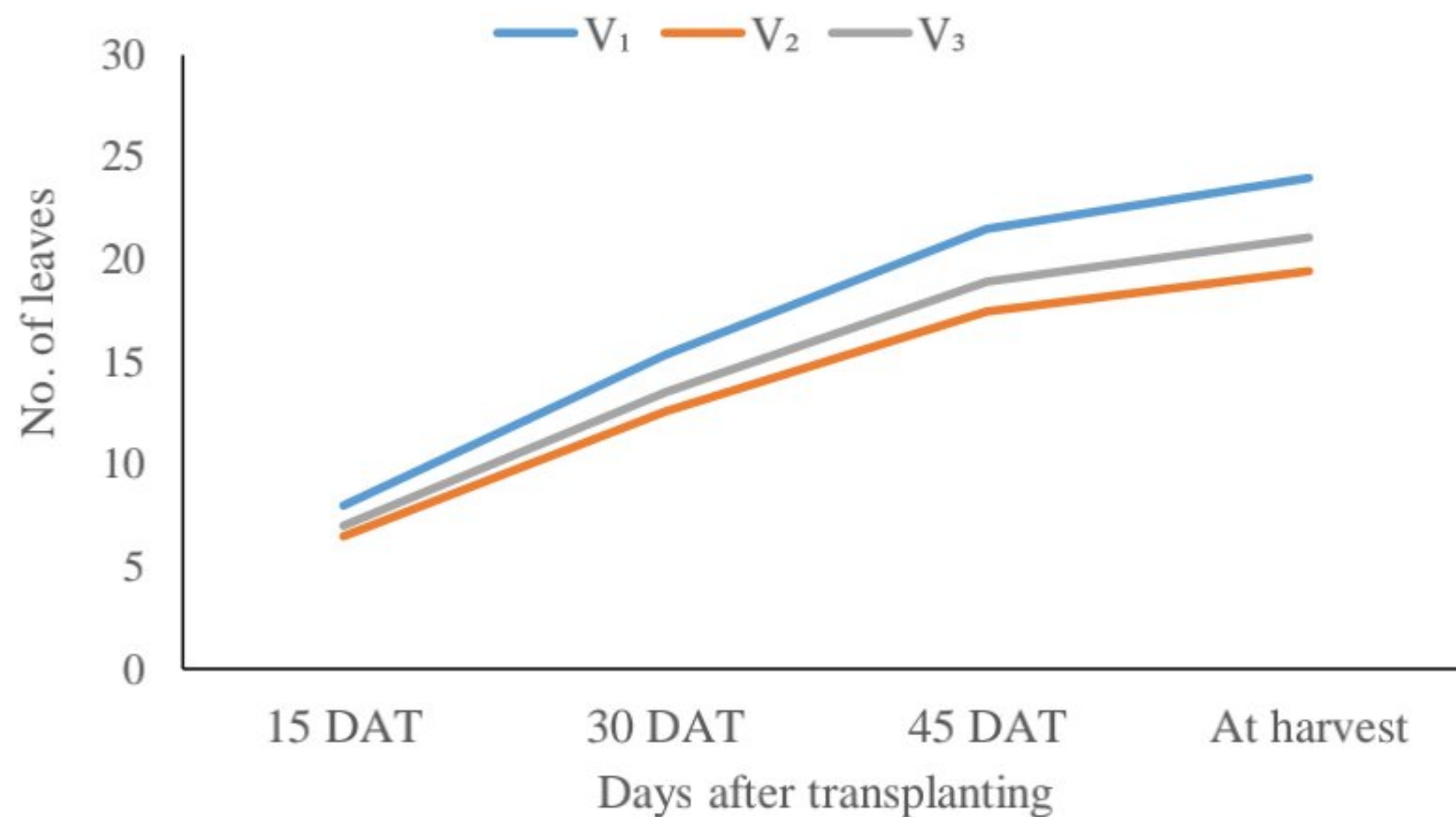


Fig. 4. Effects of varieties on the number of leaves plant⁻¹ of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

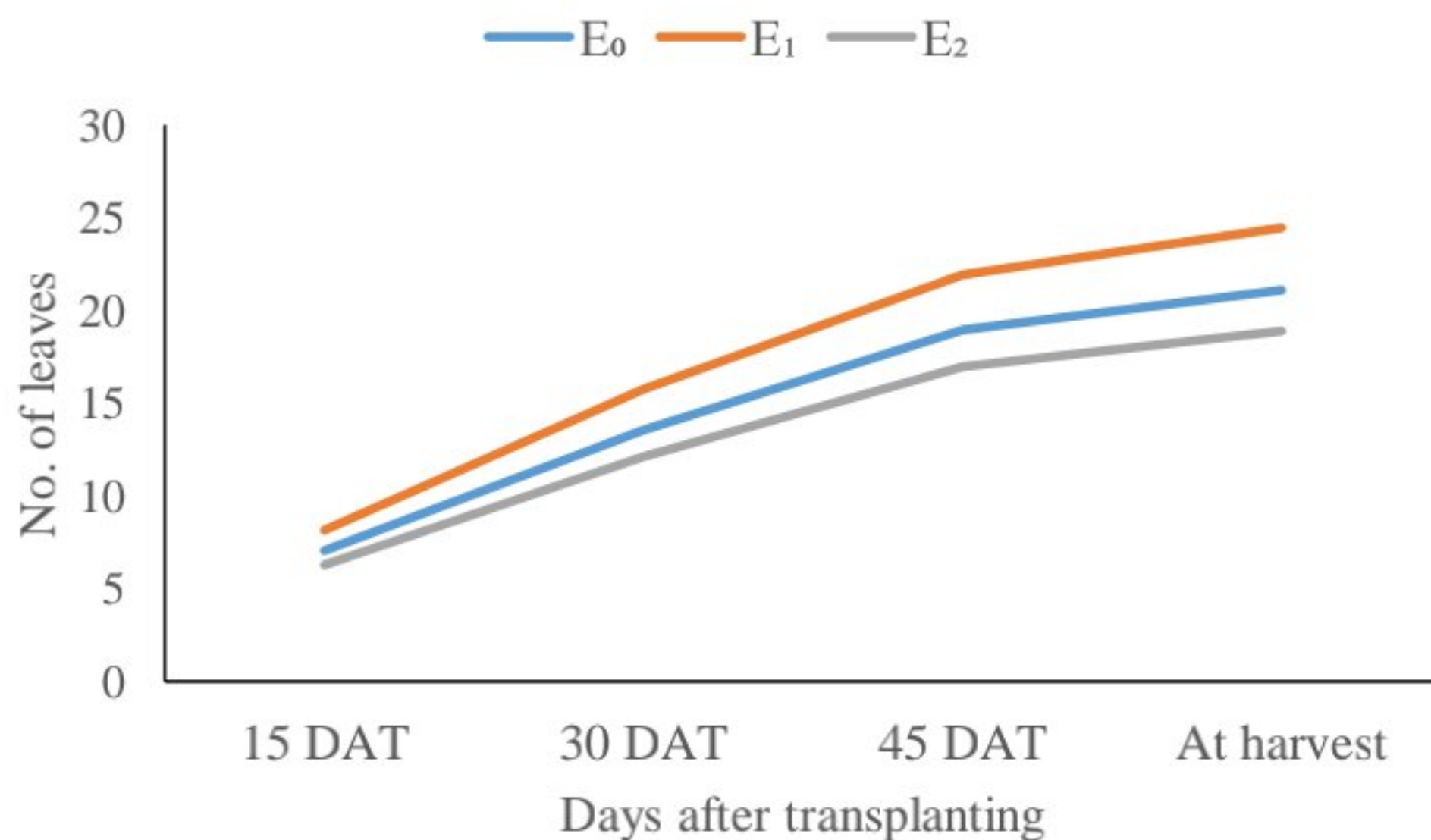


Fig. 5. Effects of ethrel on the number of leaves plant⁻¹ of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 2. Interaction effects of variety and ethrel on number of leaves plant¹ of squash at different days after transplanting (DAT)

Treatment combination	Number of leaves at			
	15 DAT	30 DAT	45 DAT	Harvest
V ₁ E ₀	7.84	15.06 b	21.09 b	23.50 b
V ₁ E ₁	9.11	17.52 a	24.53 a	27.33 a
V ₁ E ₂	7.02	13.51 bc	18.91 c	21.08 cd
V ₂ E ₀	6.37	12.24 cd	17.15 de	19.11 de
V ₂ E ₁	7.47	14.71 b	20.13 bc	22.43 bc
V ₂ E ₂	5.67	10.79 d	15.10 f	16.82 f
V ₃ E ₀	6.92	13.33 bc	18.65 cd	20.78 c-e
V ₃ E ₁	7.87	15.13 b	21.18 b	23.61 b
V ₃ E ₂	6.27	12.06 cd	16.89 e	18.82e f
CV	8.20	9.37	4.69	6.06
LSD _(0.05)	1.91	2.24	1.565	2.256

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.1.3 Leaf length

Leaf length significantly influenced by different varieties at different growth stages (Appendix VI). The highest leaf length (12.88, 33.12, 34.97 and 39.18 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the variety V₁ (GS-1) which were significantly different from all other treatments (Fig. 6). The lowest leaf length (10.36, 24.28, 26.10 and 28.73 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V₂ (Cherub) (Fig. 6).

A remarkable significant variation was observed on a leaf length at different growth stages influenced by different levels of ethrel (Appendix VI). The highest leaf length (12.66, 31.56, 33.80 cm 37.33 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E₁ (250 ppm ethrel) (Fig. 7). The lowest leaf length (10.62, 25.90, 27.07 and 30.64 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E₂ (500 ppm ethrel) (Fig. 7). Tsiakaras *et al.* (2014) also found a similar result which support the result of the present study.

Interaction effect of variety and ethrel significantly influenced on a leaf length at different growth stages (Appendix VI). The highest leaf length (14.67, 36.80, 38.72 and 43.54 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was significantly different from all other treatment combinations (Table 3). The lowest leaf length (10.13, 21.71, 23.16 and 25.69 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) (Table 3).

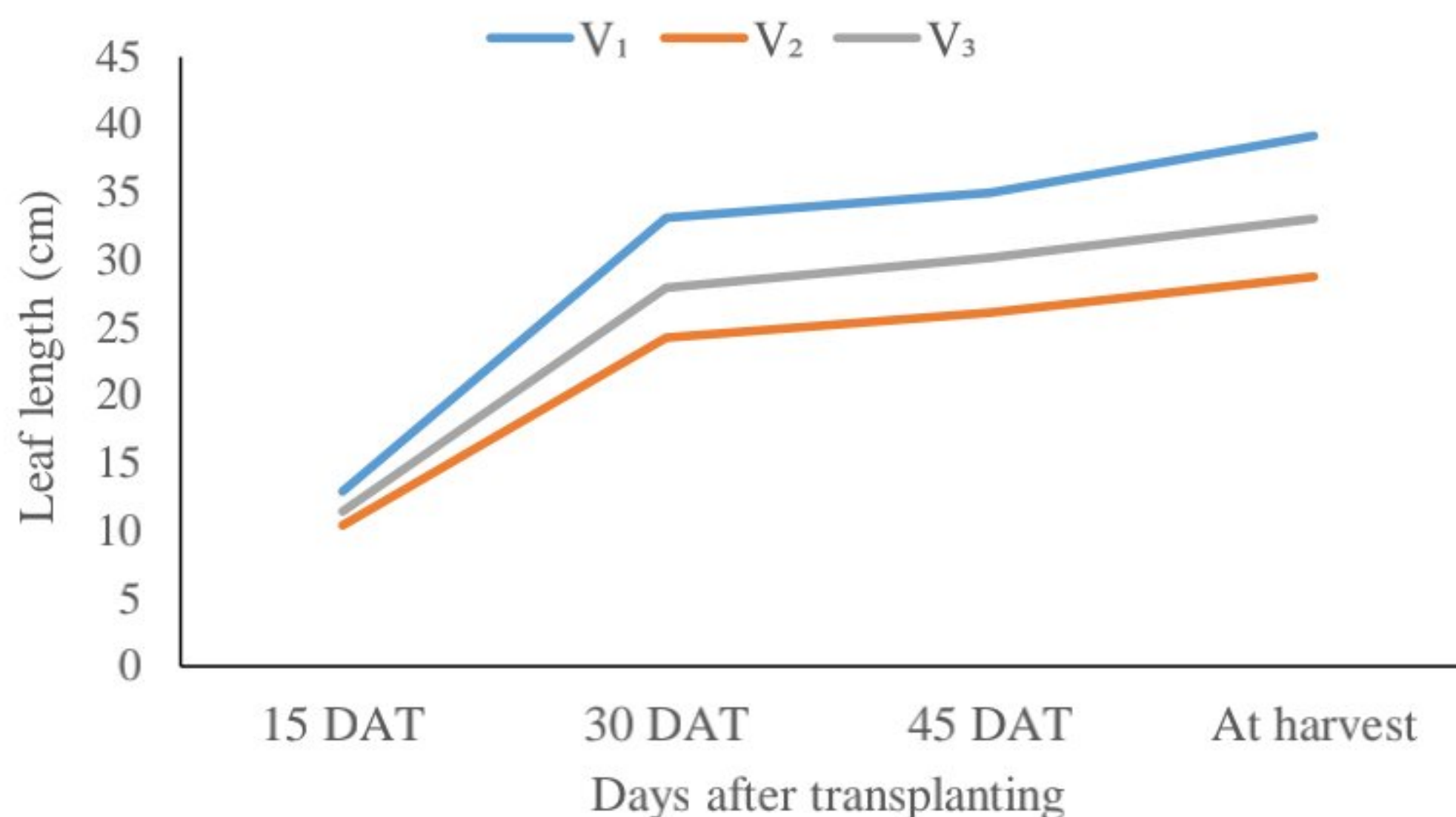


Fig. 6. Effects of varieties on the leaf length of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

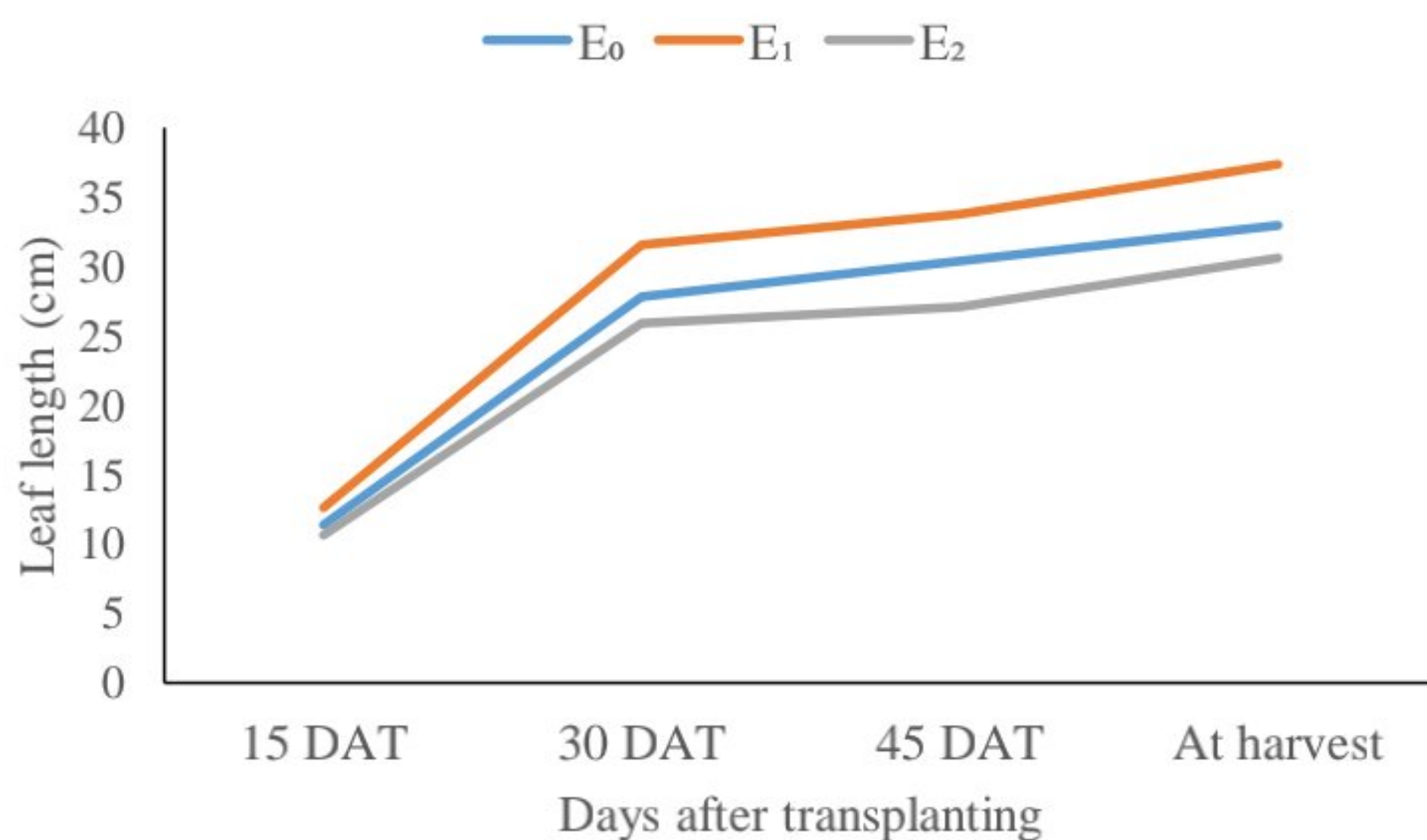


Fig. 7. Effects of ethrel on the leaf length of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 3. Interaction effects of variety and ethrel on the leaf length of squash at different days after transplanting (DAT)

Treatment combination	Leaf length (cm) at			
	15 DAT	30 DAT	45 DAT	Harvest
V ₁ E ₀	12.37 bc	31.77 b	34.80 b	37.59 b
V ₁ E ₁	14.67 a	36.80 a	38.72 a	43.54 a
V ₁ E ₂	11.60 c	30.77 b	31.38 c	36.40 b
V ₂ E ₀	10.36 e	23.72 ef	24.70 de	28.06 ef
V ₂ E ₁	10.60 e	27.42 cd	30.45 c	32.44 cd
V ₂ E ₂	10.13 e	21.71 f	23.16 e	25.69 f
V ₃ E ₀	11.47 cd	28.06 c	31.62 c	33.19 c
V ₃ E ₁	12.71 b	30.45 b	32.22 c	36.02 b
V ₃ E ₂	10.11 e	25.23 de	26.67 d	29.84 de
CV	4.68	4.71	5.70	6.00
LSD _(0.05)	0.935	2.317	2.475	2.739

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.1.4 Leaf breadth

Significant variation was observed on leaf breadth at different growth stages influenced by different varieties (Appendix VII). The highest plant height (14.59, 26.77, 29.56 and 31.13 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V₁ (GS-1) where the lowest leaf breadth (10.89, 21.61, 22.84 and 25.13 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V₂ (Cherub) at all growth stages (Fig. 8).

Leaf breadth was significantly influenced by different levels of ethrel application at different growth stages (Appendix VII). The highest leaf breadth (13.39, 26.55, 28.30 and 30.87 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E₁ (250 ppm ethrel). The lowest leaf breadth (10.68, 20.93, 22.80 and 24.34 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E₂ (500 ppm ethrel) (Fig. 9).

Interaction effect of variety and ethrel significantly influenced on leaf breadth at different growth stages (Appendix VII). Result revealed that the highest leaf breadth (16.80, 31.81, 35.50 and 37.00 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was statistically identical with the treatment combination of V₃E₃ at the time of harvest (Table 4). The lowest leaf breadth (9.17, 19.04, 21.15 and 22.15 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

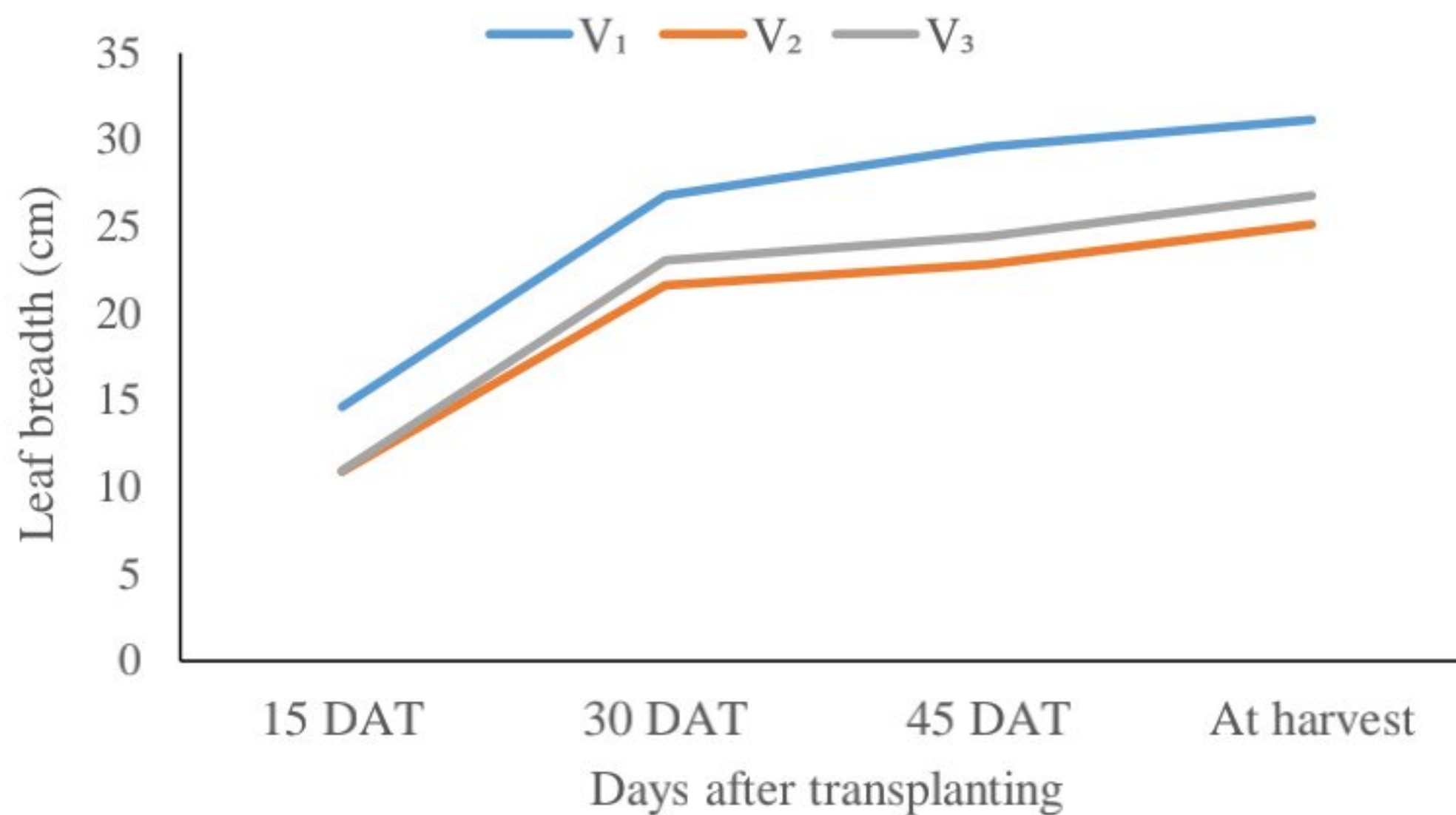


Fig. 8. Effects of varieties on the leaf breadth of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

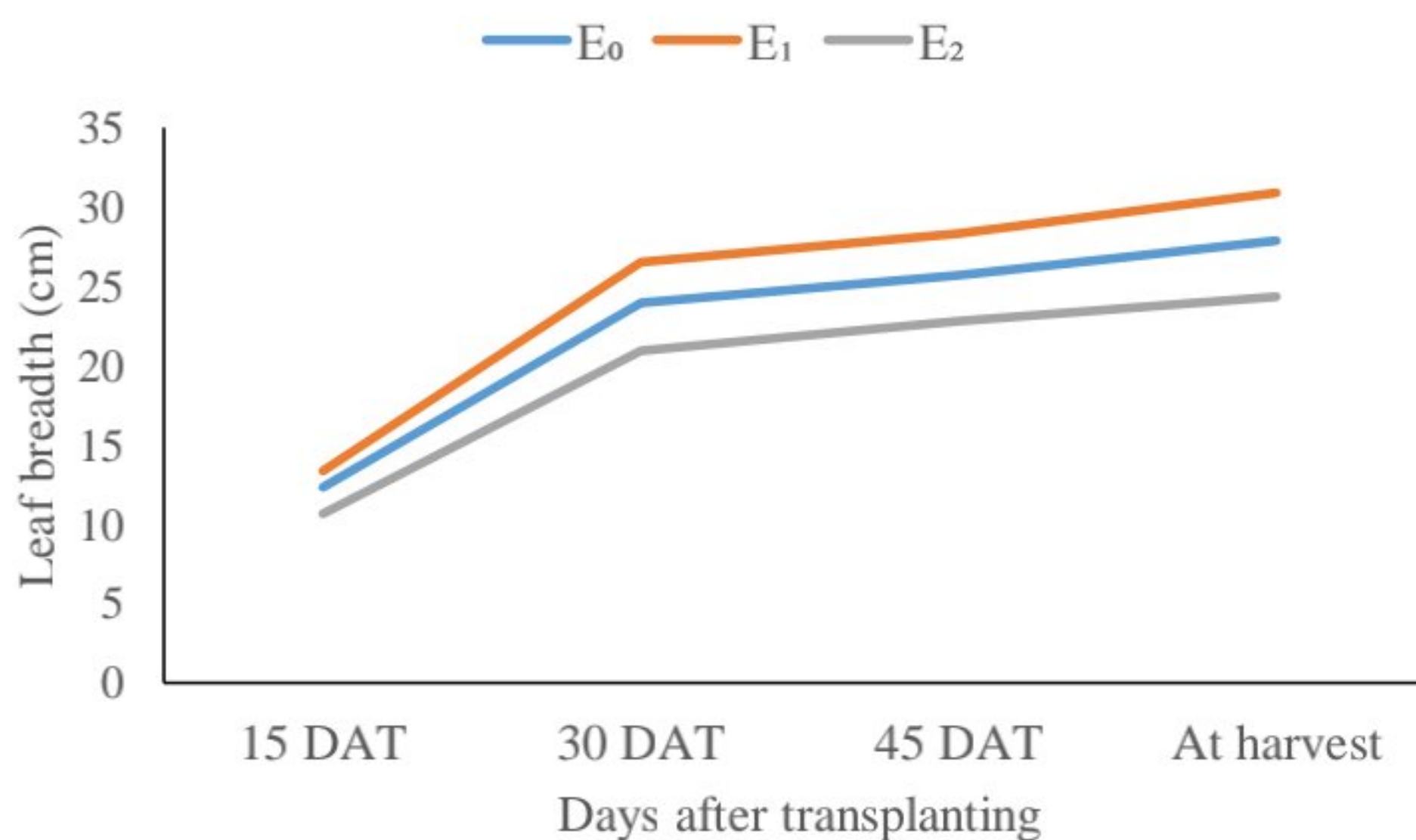


Fig. 9. Effects of ethrel on the leaf breadth of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 4. Interaction effects of variety and ethrel on leaf breadth of squash at different days after transplanting (DAT)

Treatment combination	Leaf breadth (cm) at			
	15 DAT	30 DAT	45 DAT	Harvest
V ₁ E ₀	14.15 b	25.42 b	27.15 b	29.56 b
V ₁ E ₁	16.80 a	31.81 a	35.50 a	37.00 a
V ₁ E ₂	12.80 c	23.08 c	26.04 b-d	26.84 c
V ₂ E ₀	11.69 d	21.04 d	22.16 ef	24.47 d
V ₂ E ₁	11.82 cd	24.75 bc	25.21 cd	28.78 bc
V ₂ E ₂	9.17 e	19.04 e	21.15 f	22.15 e
V ₃ E ₀	11.11 d	25.38 b	27.87 bc	29.52 b
V ₃ E ₁	11.56 d	23.08 c	24.20 de	26.84 c
V ₃ E ₂	10.08 e	20.67 de	21.22 f	24.05 de
CV	6.02	4.68	5.67	5.68
LSD _(0.05)	0.990	1.929	2.076	2.243

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.1.5 Stem diameter

Stem base diameter was significantly influenced by different varieties at different growth stages (Appendix VIII). However, the highest stem diameter (1.14, 1.50, 2.00 and 2.40 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V_1 (GS-1) and the lowest stem diameter (0.93, 1.25, 1.62 and 1.95 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the variety V_2 (Cherub) (Fig. 10).

Different levels of ethrel have significant variation on stem diameter at different growth stages (Appendix VIII). The highest stem diameter (1.16, 1.54, 2.04 and 2.44 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the treatment E_1 (250 ppm ethrel) which was significantly different from all other treatments where the lowest stem diameter (0.90, 1.21, 1.58 and 1.89 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the treatment E_2 (500 ppm ethrel) (Fig. 11).

Stem base diameter at different growth stages were significantly influenced by the interaction effect of variety and ethrel except 15 DAT (Appendix VIII). The highest stem base diameter (1.29, 1.71, 2.27 and 2.73 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were found from the combination of V_1E_1 (variety GS-1 with 250 ppm ethrel) where the lowest stem base diameter (0.80, 1.13, 1.41 and 1.69 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) were noted from the combination of V_2E_2 (variety Cherub with 500 ppm ethrel) (Table 5).

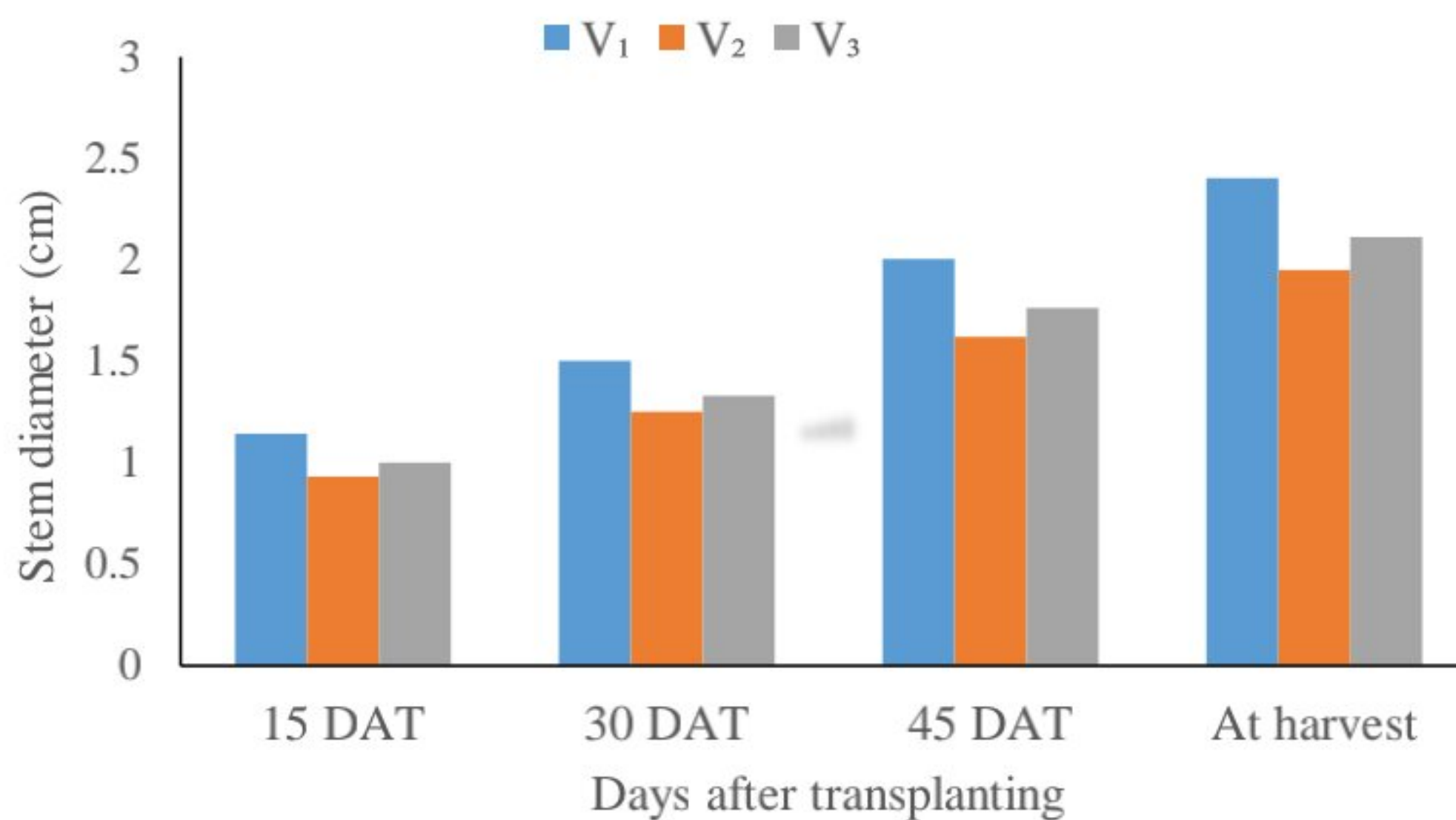


Fig. 10. Effects of variety on the stem diameter (cm) of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

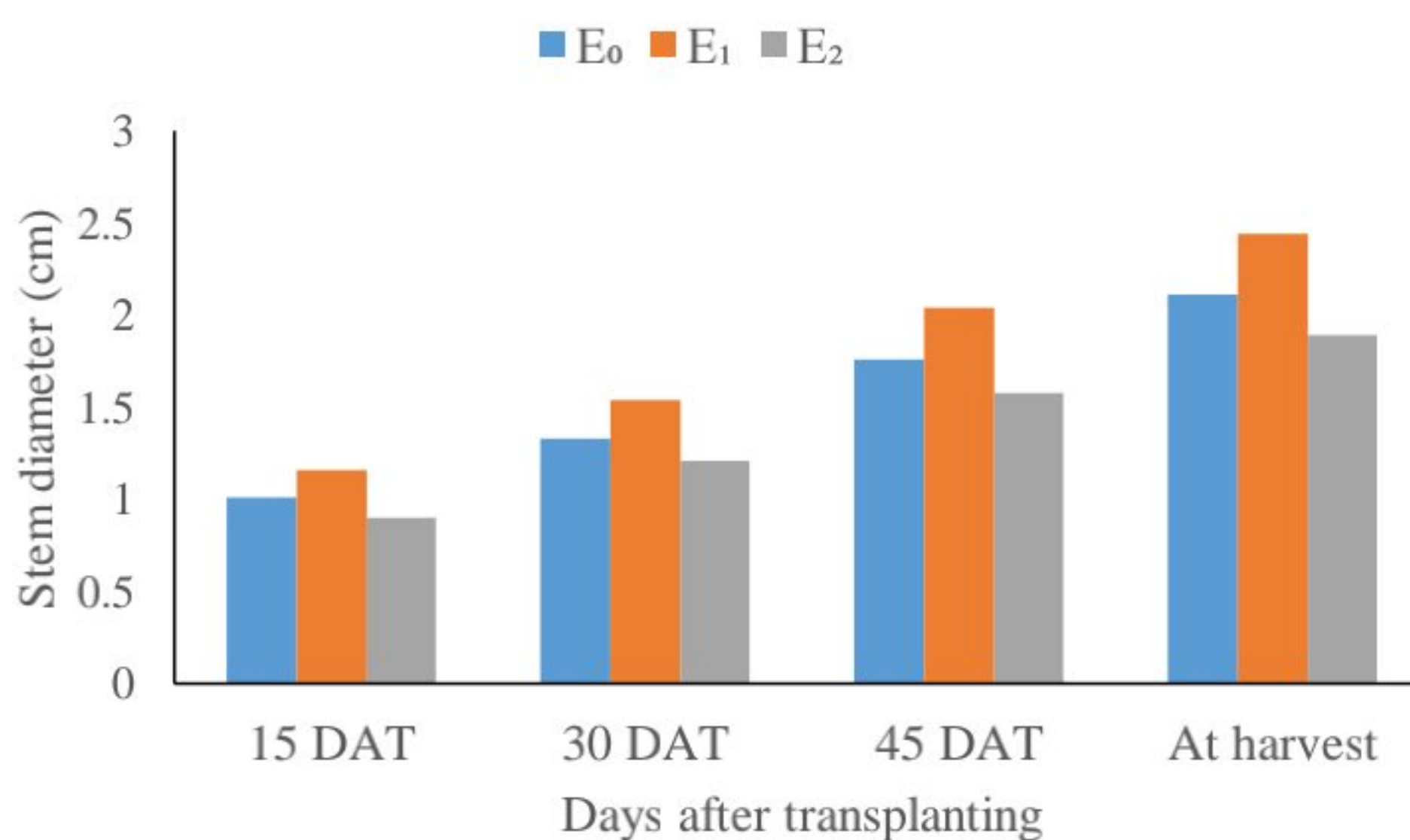


Fig. 11. Effects of ethrel on the stem diameter (cm) of squash at different days after transplanting (DAT)

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 5. Interaction effects of variety and ethrel on the stem diameter (cm) of squash at different days after transplanting (DAT)

Treatment combination	Stem diameter (cm) at			
	15 DAT	30 DAT	45 DAT	Harvest
V ₁ E ₀	1.13	1.47 b	1.96 b	2.35 b
V ₁ E ₁	1.29	1.71 a	2.27 a	2.73 a
V ₁ E ₂	1.00	1.33 c	1.76 c	2.11 c
V ₂ E ₀	0.91	1.20 de	1.59 de	1.91 de
V ₂ E ₁	1.06	1.41 bc	1.87 bc	2.24 bc
V ₂ E ₂	0.80	1.13 e	1.41 f	1.69 f
V ₃ E ₀	0.99	1.31 cd	1.73 cd	2.08 cd
V ₃ E ₁	1.13	1.48 b	1.97 b	2.36 b
V ₃ E ₂	0.89	1.18 e	1.57 e	1.88 e
CV	4.70	4.86	5.66	7.70
LSD _(0.05)	0.083	0.114	0.144	0.174

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.2 Yield contributing parameters and yield

4.2.1 Days for the 1st male flowering

Varieties had significant variation on days for 1st male flowering at different growth stages (Appendix IX). The smallest days for 1st male flowering (10.42) was found from the variety V₁ (GS-1) which was significantly different from all other treatments (Table 6). The longest days for 1st male flowering (14.43) was found from the variety V₂ (Cherub).

Significant variation was observed on days for 1st male flowering influenced by different levels of ethrel (Appendix IX). The smallest days for 1st male flowering (10.17) was found from the treatment E₁ (250 ppm ethrel) and the longest days for 1st male flowering (13.90) was found from the treatment E₂ (500 ppm ethrel) (Table 7).

Interaction effect of variety and ethrel had significantly influenced on a days for 1st male flowering (Appendix IX). The smallest days for 1st male flowering (9.26) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was statistically similar with the combinations V₃E₁ (Table 8). The longest days for 1st male flowering (16.76) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

4.2.2 Days for the 1st female flowering

Remarkable variation on days for 1st female flowering influenced by different varieties at different growth stages and the variation was significant (Appendix IX). The lowest days for 1st female flowering (12.61) was found from the variety V₁ (GS-1) which was significantly different from all other treatments (Table 6). The highest days for 1st female flowering (17.46) was found from the variety V₂ (Cherub).

Table 6. Effect of the variety on the flowering time of squash

Varieties	Days for the 1 st male flowering	Days for the 1 st female flowering	Days for the 50% male flowering	Days for the 50% female flowering
V ₁	10.42 c	12.61 c	20.83 c	23.02 c
V ₂	14.43 a	17.46 a	28.86 a	31.89 a
V ₃	11.69 b	14.15 b	23.38 b	25.95 b
CV	5.79	5.78	6.71	6.30
LSD _(0.05)	0.704	0.851	1.633	1.806

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

Table 7. Effect of ethrel on the flowering time of squash

Ethrel	Days for the 1 st male flowering	Days for the 1 st female flowering	Days for the 50% male flowering	Days for the 50% female flowering
E ₀	12.47 b	15.09 b	24.94 b	27.56 b
E ₁	10.17 c	12.30 c	20.34 c	22.47 c
E ₂	13.90 a	16.82 a	27.80 a	30.83 a
CV	5.79	5.78	6.71	6.30
LSD _(0.05)	0.074	0.851	1.633	1.806

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

Table 8. Interaction effects of the variety and ethrel on the flowering time of squash

Treatment combination	Days for the 1 st male flowering	Days for the 1 st female flowering	Days for the 50% male flowering	Days for the 50% female flowering
V ₁ E ₀	10.06 e	12.18 e	20.12 ef	22.23 ef
V ₁ E ₁	9.26 e	11.21 e	18.53 f	20.47 f
V ₁ E ₂	11.93 cd	14.43 cd	23.85 cd	26.36 cd
V ₂ E ₀	15.17 b	18.36 b	30.34 b	33.53 b
V ₂ E ₁	11.36 d	13.74 d	22.72 de	25.11 de
V ₂ E ₂	16.76 a	20.28 a	33.52 a	37.04 a
V ₃ E ₀	12.18 cd	14.74 cd	24.36 cd	26.91 cd
V ₃ E ₁	9.88 e	11.96 e	19.76 f	21.84 f
V ₃ E ₂	13.02 c	15.75 e	26.04 c	29.10 c
CV	5.79	5.78	6.71	6.30
LSD _(0.05)	1.221	1.475	2.829	3.128

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

Significant variation was observed on days for 1st female flowering influenced by different levels of ethrel (Appendix IX). The least days for 1st female flowering (12.30) was found from the treatment E₁ (250 ppm ethrel) and the highest days for 1st female flowering (16.82) was found from the treatment E₂ (500 ppm ethrel) (Table 7). Reduction in days to first female flower induction due to ethrel application has been reported earlier by Kshirsagar *et al.* (1995); Bhandary *et al.* (1974) and Kooner, *et al.* (2000). This may be due to the fact that the plants receiving treatments are able to build up suitable carbohydrate reserves resulting in early flowering as well as increased number of female flower and fruit set.

Interaction effect of variety and ethrel significantly influenced on a days for 1st female flowering (Appendix IX). The lowest days for 1st female flowering (11.21) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was statistically similar with the combinations V₃E₁ (Table 8). The highest days for 1st female flowering (20.28) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

4.2.3 Days for 50% male flowering

Significant variation on days for 50% male flowering was noted for different varieties at various growth stages (Appendix IX). The least days for 50% male flowering (20.83) was found from the variety V₁ (GS-1) which was significantly different from all other treatments and the maximum days for 50% male flowering (28.86) was found from the variety V₂ (Cherub) which was both significantly different from all other treatments (Table 6).

Different levels of ethrel application resulted significant variation on the days for 50% 1st male flowering (Appendix IX). The least days for 50% 1st male flowering (20.34) was found from the treatment E₁ (250 ppm ethrel) but the

maximum days for 50% male flowering (27.80) was found from the treatment E₂ (500 ppm ethrel) (Table 7).

Days for 50% male flowering were significantly influenced by the interaction effect of variety and ethrel (Appendix IX). The least days for 50% male flowering (18.53) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was statistically similar with the combinations V₃E₂ (Table 8). The longest days for 50% 1st male flowering (33.52) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

4.2.4 Days for 50% female flowering

There was a significant variation on days for 50% female flowering influenced by different varieties at different growth stages (Appendix IX). The least days for 50% 1st female flowering (23.02) was found from the variety V₁ (GS-1) which was significantly different from all other treatments. The maximum days for 50% female flowering (31.89) was found from the variety V₂ (Cherub) which was also significantly different from all other treatments (Table 6).

Significant variation was observed on days for 50% female flowering influenced by different levels of ethrel (Appendix IX). The lowest days for 50% 1st female flowering (22.47) was found from the treatment E₁ (250 ppm ethrel) and the lowest days for 50% female flowering (30.83) was found from the treatment E₂ (500 ppm ethrel) (Table 7).

Days for 50% female flowering were significantly influenced by the interaction effect of variety and ethrel (Appendix IX). The lowest days for 50% female flowering (20.47) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was statistically similar with the combinations V₃E₁ (Table 8). The highest days for 50% female flowering (37.04) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

4.2.5 Number of male flowers plant⁻¹

Remarkable variation was observed on number of male flowers plant⁻¹ influenced by different varieties (Appendix X). The highest number of male flowers plant⁻¹ (9.52) was found from V₁ (GS-1) where the lowest number of male flowers plant⁻¹ (8.37) was found from V₂ (Cherub) (Fig. 12).

Significant influence was noted on a number of male flowers plant⁻¹ affected by different levels of ethrel (Appendix X). The highest number of male flowers plant⁻¹ (9.58) was found from E₁ (250 ppm ethrel) where the lowest number of male flowers plant⁻¹ (9.58) was found from E₂ (500 ppm ethrel) (Fig. 13). Thomas (2008) also reported the effective role of ethrel in modifying sex than GA₃ both in term of pistillate flower induction as well as percentage pistillate flowers developing into fruits.

Number of male flowers plant⁻¹ was significantly influenced by the interaction effect of variety and ethrel (Appendix X). The highest number of male flowers plant⁻¹ (10.42) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) which was statistically identical with V₁E₀ (Table 9). The lowest number of male flowers plant⁻¹ (7.69) was found from V₂E₂ (variety Cherub with 500 ppm ethrel) which was statistically identical with V₃E₂ (Table 9).

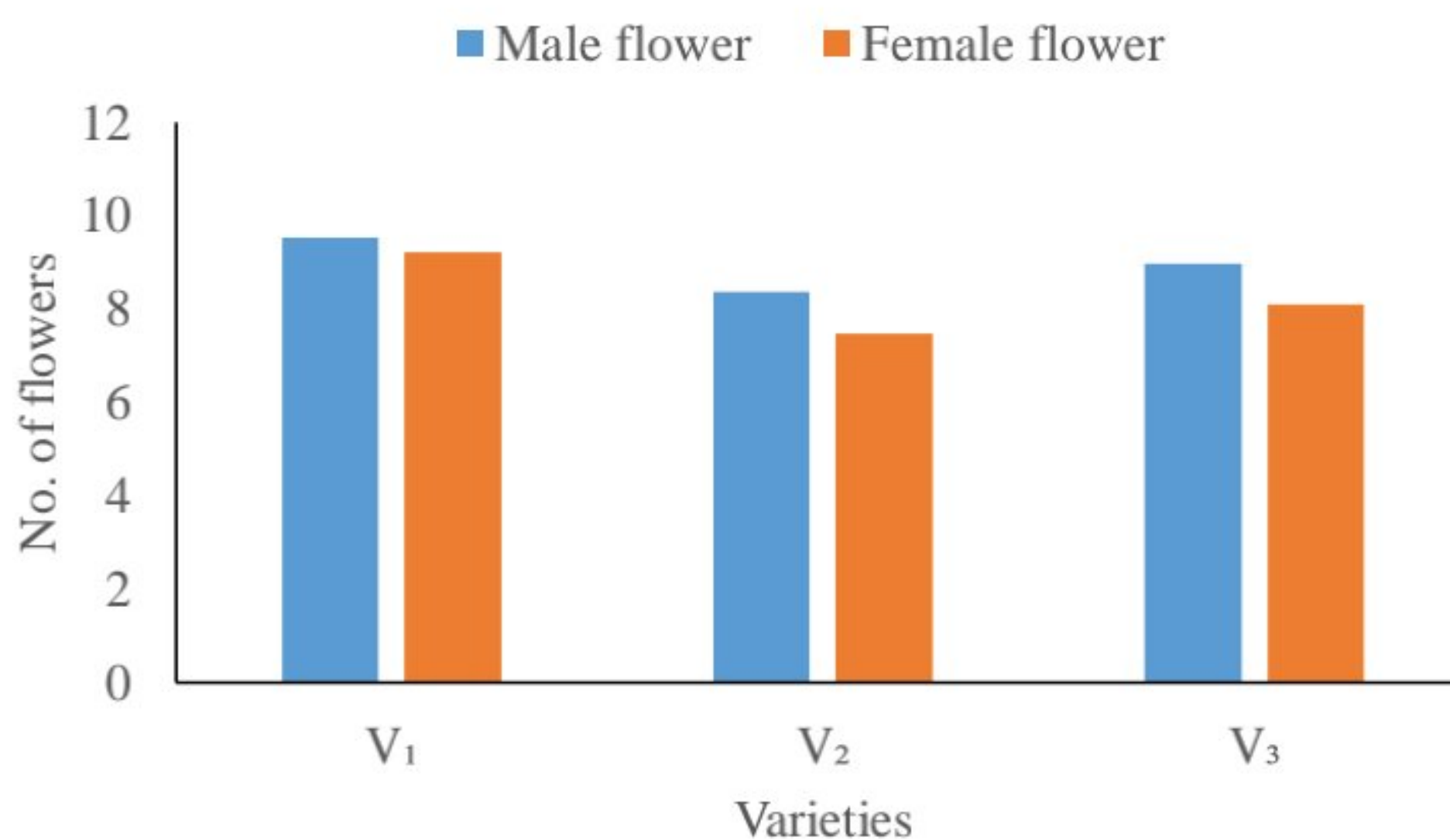


Fig. 12. Effect of variety on the number of male and female flowers of squash Vertical bar represented LSD at 0.05 level
(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

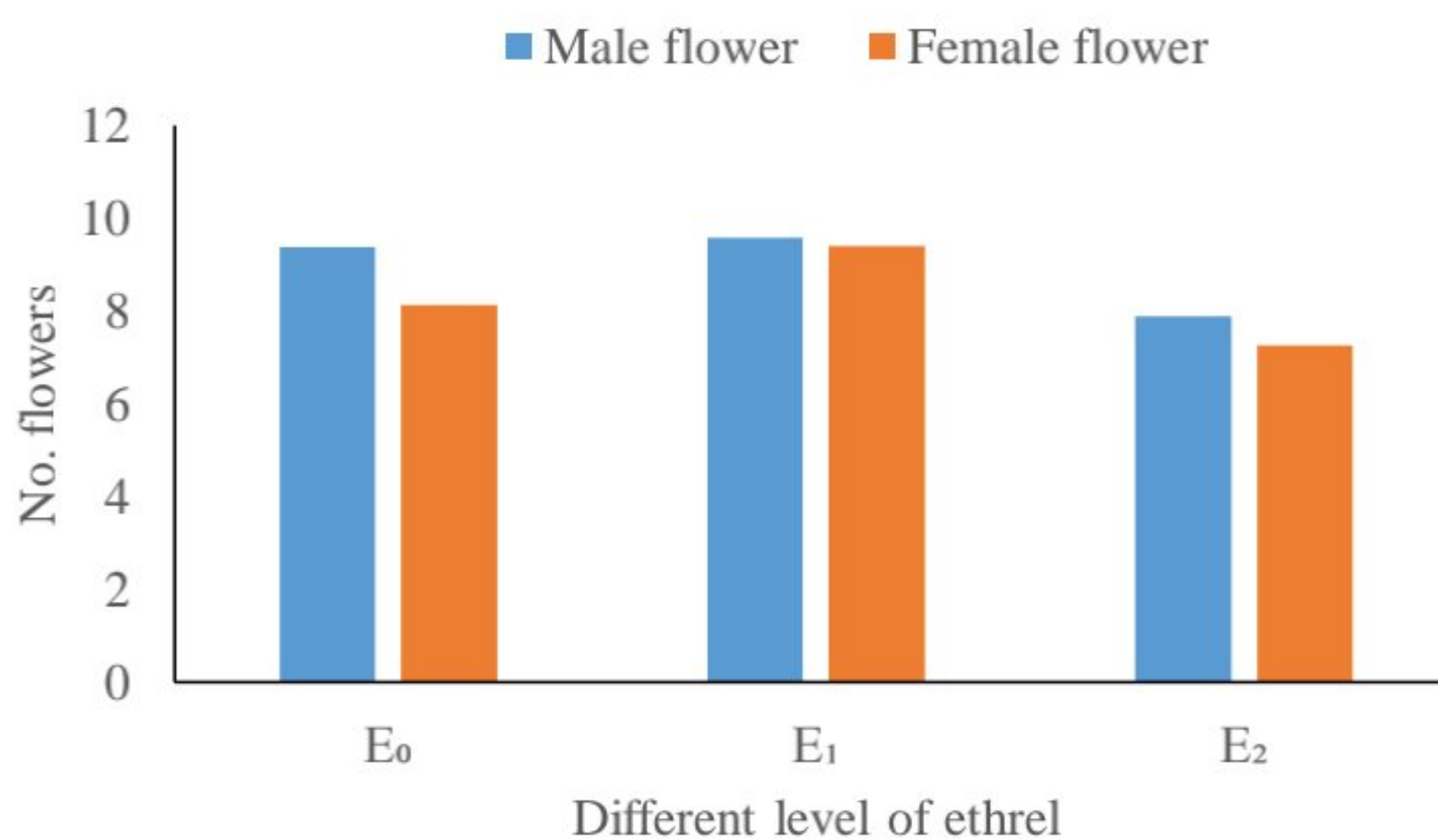


Fig. 13. Effect of ethrel on the number of male and female flowers of squash Vertical bar represented LSD at 0.05 level
(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 9. Interaction effects of variety and ethrel on the flower and fruit characters of squash

Treatment combination	Number of male flowers	Number of female flowers	Number of fruits plant ⁻¹	Fruit length (cm)	Fruit diameter (cm)
V ₁ E ₀	10.70 a	9.04 b	5.51 b	23.50 b	4.53 b
V ₁ E ₁	10.92 a	10.51 a	6.45 a	26.26 a	5.16 a
V ₁ E ₂	8.27 cd	8.11 c	4.89 d	21.08 c-e	4.13 c
V ₂ E ₀	8.70 c	7.35 de	4.16 e	19.11 f	3.72 d
V ₂ E ₁	8.72 c	8.63 bc	5.08 cd	22.43 b-d	4.02 cd
V ₂ E ₂	7.69 d	6.47 f	3.54 f	16.82 g	3.02 e
V ₃ E ₀	8.74 c	8.00 cd	4.82 d	20.78 d-f	4.67 b
V ₃ E ₁	9.40 a	9.08 b	5.32 bc	22.61 bc	4.92 ab
V ₃ E ₂	7.72 d	7.23 e	4.31 e	19.82 ef	3.66 d
CV	4.68	6.68	5.70	4.02	5.39
LSD _(0.05)	0.726	0.670	0.398	1.731	0.392

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.2.6 Number of female flowers plant⁻¹

Significant variation was remarked on a number of female flower plant⁻¹ as influenced by different varieties (Appendix X). The highest number of female flowers plant⁻¹ (9.22) was found from the variety V₁ (GS-1) where the lowest number of female flowers plant⁻¹ (7.48) was found in V₂ (Cherub) (Fig.12).

Number of female flower plant⁻¹ was found significant with the application of different levels of ethrel (Appendix X). The highest number of female flowers plant⁻¹ (9.41) was found from E₁ (250 ppm ethrel) and the lowest number of female flowers plant⁻¹ (7.89) was found from E₂ (500 ppm ethrel) which was also significantly different from all other treatments (Fig. 13). Result explained that morphologically, all cucumber floral buds are initially hermaphroditic with both male and female reproductive organs, but increase in endogenous ethylene concentration directly disturb stamen development, as among all floral organs, stamen development is more sensitive to exogenous ethylene treatment (Duan *et al.* 2008, Liu *et al.* 2008).

Remarkable variation was identified on a number of female flower plant⁻¹ due to the interaction effect of variety and ethrel (Appendix X). The highest number of female flowers plant⁻¹ (10.51) was found from the V₁E₁ (variety GS-1 with 250 ppm ethrel) which was significantly different from all other treatment combinations (Table 9). In contrast, the lowest number of female flowers plant⁻¹ (6.47) was found from V₂E₂ (variety Cherub with 500 ppm ethrel).

4.2.7 Number of fruits plant⁻¹

A variation on a total number of fruits plant⁻¹ was noted influenced by different varieties (Appendix X). The highest total number of fruits plant⁻¹ (5.62) was found from the variety V₁ (GS-1) where the lowest total number of fruits plant⁻¹ (4.26) was found from the variety V₂ (Cherub) (Fig. 14). Vadigeri *et al.* (2001)

who also observed differential response in number of fruits of cucumber varieties to ethrel concentrations.

Different levels of ethrel found significant effect on a total number of fruits plant⁻¹ (Appendix X). The highest total number of fruits plant⁻¹ (5.62) was found from the treatment E₁ (250 ppm ethrel) and the lowest total number of fruits plant⁻¹ (4.26) was found from the treatment E₂ (500 ppm ethrel) (Fig. 15). Ranjit and Satya (2006) reported that application ethrel at 250 ppm at the 2- and 4-leaf stages was optimum for enhancing number of fruits per plant and total fruit yield per plant in pumpkin under open field condition. Hilli *et al.* (2008) recorded significant increase in test weight and seed germination of both summer and winter sown ridge gourd with the foliar application of ethrel at 500 ppm. While Thomas (2008) did not observe any significant change in seed size and viability due ethrel or GA₃ treatments but observed the effective role of ethrel in modifying sex than GA₃ both in term of pistillate flower induction as well as percentage pistillate flowers developing into fruits. Significant increase in number of fruits with ethrel at 400 ppm was also reported by Vadigeri *et al.* (2001).

Significant influence was noted on a total number of fruits plant⁻¹ affected by the interaction effect of variety and ethrel (Appendix X). The highest total number of fruits plant⁻¹ (6.45) was found from V₁E₁ (variety GS-1 with 250 ppm ethrel) and the lowest total number of fruits plant⁻¹ (3.54) was found from V₂E₂ (variety Cherub with 500 ppm ethrel) (Table 9).

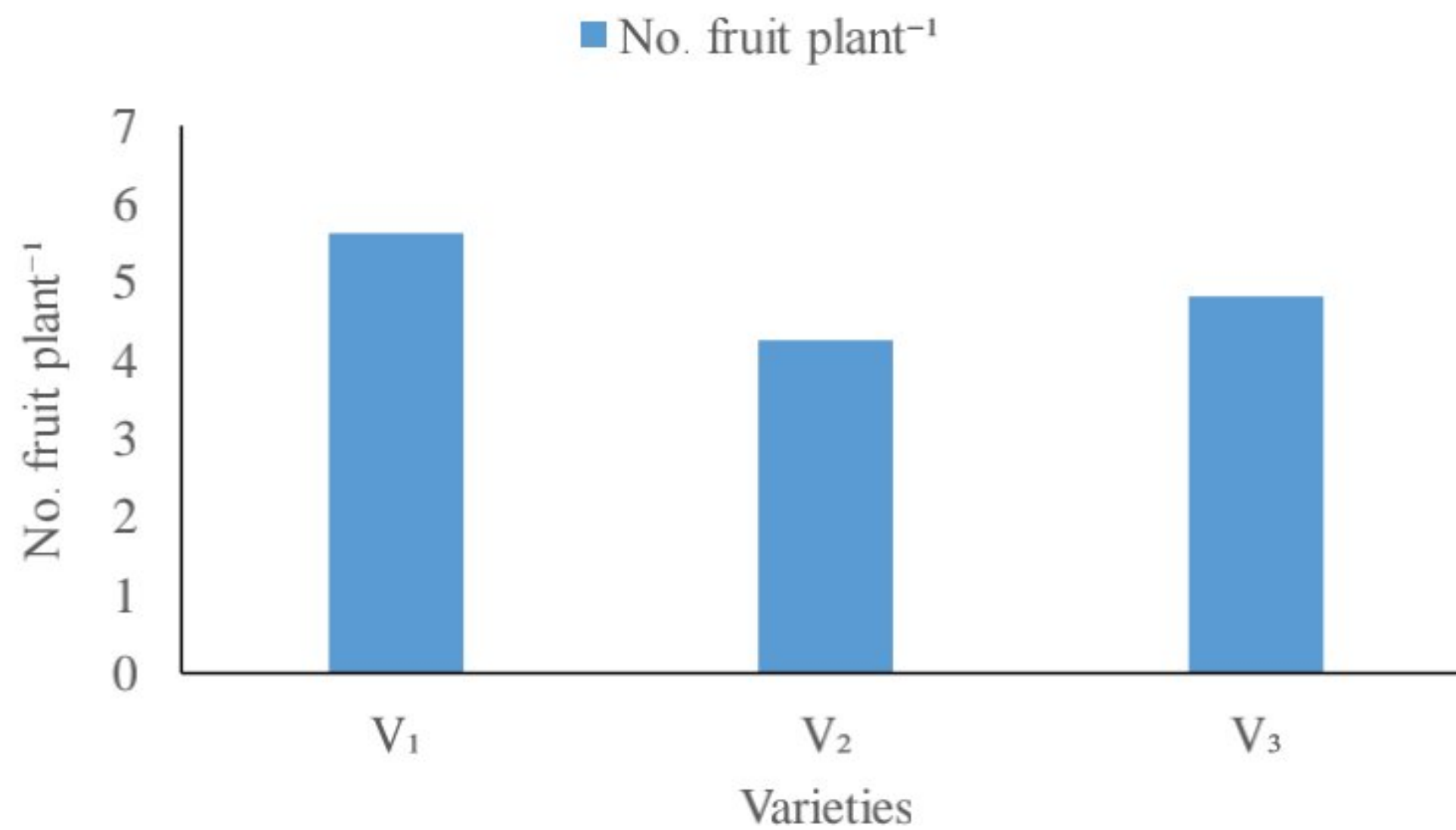


Fig. 14. Effect of variety on the number of fruits plant⁻¹ of squash

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

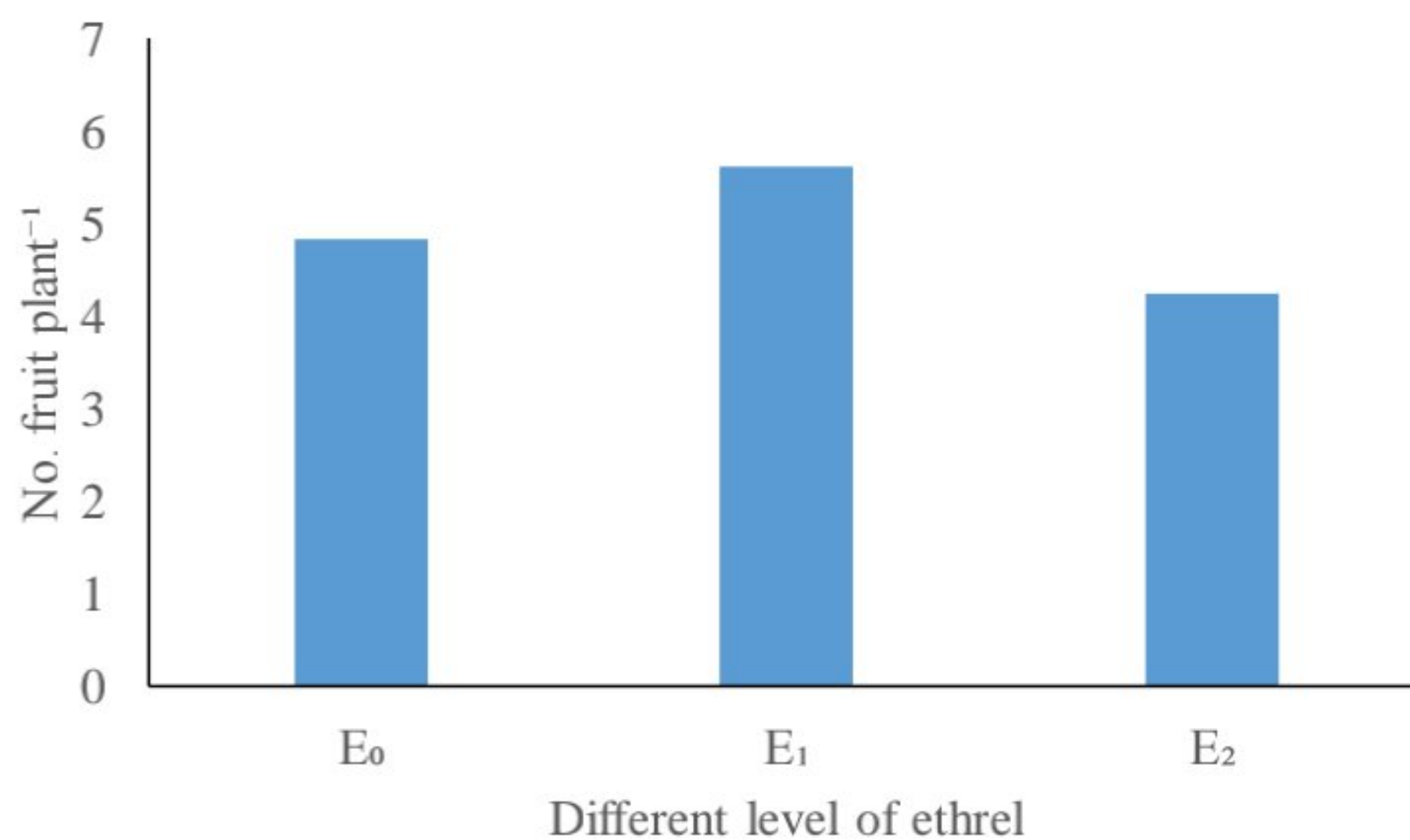


Fig. 15. Effect of ethrel on the number of fruits plant⁻¹ of squash

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

4.2.8 Fruit length

Remarkable variation was observed for the fruit length as influenced by different varieties (Appendix X). However, the highest fruit length (23.61 cm) was found from the variety V₁ (GS-1) but the lowest fruit length (19.45 cm) was found from the variety V₂ (Cherub) (Table 10).

Significant influence was noted on the fruit length as affected by different levels of ethrel (Appendix X). The highest fruit length (21.13 cm) was found from E₁ (250 ppm ethrel) where the lowest fruit length (19.24 cm) was found from E₂ (500 ppm ethrel) which was statistically identical with G₃ (400 ppm GA₃) (Table 11). The increased fruit length due to ethrel treatments are in line with the findings of Rafeekher *et al.* (2001) and Vadigeri *et al.* (2001) and increase in fruit diameter by ethrel as reported by Singh and Choudhary (1989).

The fruit length was found to significantly vary due to the interaction of variety and ethrel (Appendix X). The highest fruit length (26.26 cm) was found from V₁E₁ (variety GS-1 with 250 ppm ethrel) which was significantly different from all other treatment combinations (Table 12). The lowest fruit length (16.82 cm) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) (Table 12).

Table 10. Effects of variety on the fruit length and diameter of squash

Varieties	Fruit length (cm)	Fruit diameter (cm)
V ₁	23.61 a	4.60 a
V ₂	19.45 c	3.59 b
V ₃	21.07 b	4.41 a
CV	4.02	5.39
LSD _(0.05)	0.999	0.226

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

Table 11. Effects of ethrel on the fruit length and diameter of squash

Ethrel	Fruit length (cm)	Fruit diameter (cm)
E ₀	21.13b	4.30b
E ₁	23.76a	4.70a
E ₂	19.24c	3.60c
CV	4.02	5.39
LSD _(0.05)	0.999	0.226

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

Table 12. Interaction effects of variety and ethrel on the flower and fruit characters of squash

Treatment combination	Fruit length (cm)	Fruit diameter (cm)
V ₁ E ₀	23.50 b	4.5 3b
V ₁ E ₁	26.26 a	5.16 a
V ₁ E ₂	21.08 c-e	4.13 c
V ₂ E ₀	19.11 f	3.72 d
V ₂ E ₁	22.43 b-d	4.02 cd
V ₂ E ₂	16.82 g	3.02 e
V ₃ E ₀	20.78 d-f	4.67 b
V ₃ E ₁	22.61 bc	4.92 ab
V ₃ E ₂	19.82 ef	3.66 d
CV	4.02	5.39
LSD _(0.05)	1.731	0.392

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

4.2.9 Fruit diameter

Significant variation was remarked on fruit diameters influenced by different varieties (Appendix X). The highest fruit diameter (4.60 cm) was found from the variety V₁ (GS-1) where the lowest fruit diameter (3.59 cm) was found from the variety V₂ (Cherub) (Table 10).

Fruit diameter was found to vary significantly with the application of different levels of ethrel (Appendix X). However, the highest fruit diameter (4.70 cm) was found from E₁ (250 ppm ethrel) but the lowest fruit diameter (3.60 cm) was found from E₂ (500 ppm ethrel) (Table 11). Vadigeri *et al.* (2001) and Singh and Singh (1984), however, reported about the increase in diameter of fruits with ethrel 400 ppm and 50-100 ppm, respectively.

The interaction effect of variety and ethrel was found significant on the fruit diameter (Appendix X). The highest fruit diameter (5.16 cm) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) (Table 12). The lowest fruit diameter (3.02 cm) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

4.2.10 Individual fruit weight

A variation in the individual fruit weight was found to be influenced by different varieties (Appendix XI). However, the highest individual fruit weight (434.59 g) was found from the variety V₁ (GS-1) while the lowest individual fruit weight (305.80 g) was found from the variety V₂ (Cherub) (Fig. 16).

The recorded data on individual fruit weight was significant with the application of different levels of ethrel (Appendix XI). The highest individual fruit weight (416.09 g) was found from E₁ (250 ppm ethrel) where the lowest individual fruit weight (337.36 g) was found from E₂ (500 ppm ethrel) (Fig. 17). Similar results were obtained by number of workers. Verma and Choudhary (1980); Singh and

Choudhary (1989) obtained the highest fruit weight in cucumber when sprayed at 2-4 leaf stage with ethrel @ 50-200 ppm while Vadigeri, *et al.* (2001) and Rafeekher *et al.* (2001) reported about the reduction in fruit length of cucumber with ethrel treatments.

Significant influence was noted on the individual fruit weight as affected by the interaction effect of variety and ethrel (Appendix XI). The highest individual fruit weight (483.08 g) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) (Table 13). The lowest individual fruit weight (295.59 g) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) which was statistically similar to the treatment combination of V₂E₀.

4.2.11 Percent (%) fruit dry matter

The considerable influence was observed on % fruit dry matter in different varieties (Appendix XI). However, the highest % fruit dry matter (6.40%) was found in the variety V₁ (GS-1) and the lowest % fruit dry matter (5.34%) was found in the variety V₂ (Cherub) (Table 14).

Significant variation was identified on % fruit dry matter due to the effect of different levels of ethrel (Appendix XI). The highest fruit dry matter (6.41%) was found from E₁ (250 ppm ethrel) but the lowest fruit dry matter (5.50%) was found from E₂ (500 ppm ethrel) (Table 15).

Significant variation was found on the % fruit dry weight as affected by the interaction effect of variety and ethrel (Appendix XI). The highest fruit dry matter (7.22%) was found from the combination V₁E₁ (variety GS-1 with 250 ppm ethrel) which was significantly different from all other treatment combinations where the lowest fruit dry matter (4.94%) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) which was statistically identical with the treatment combination V₂E₀ (Table 13).

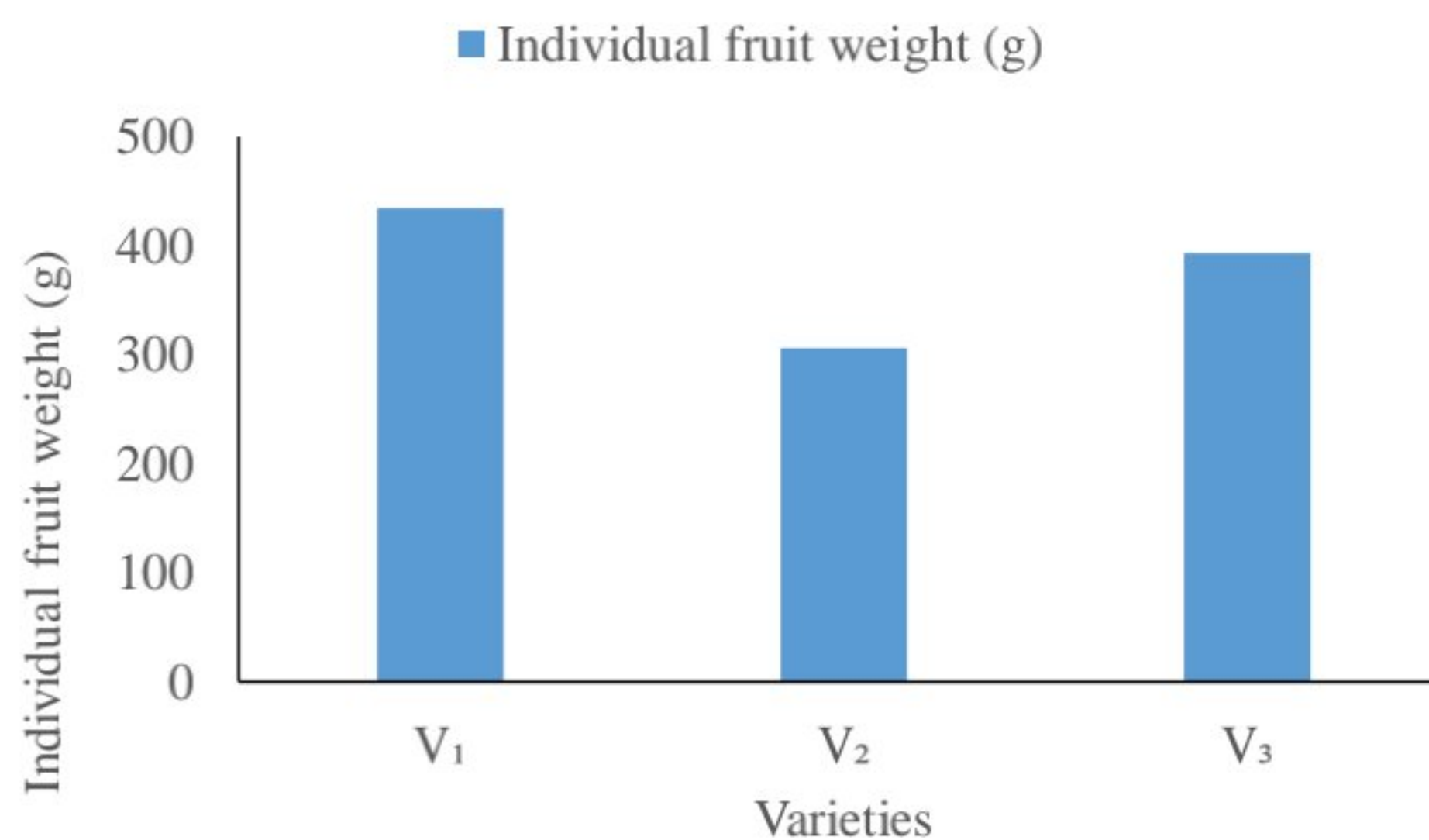


Fig. 16. Effect of variety on the individual fruit weight (g) of squash

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

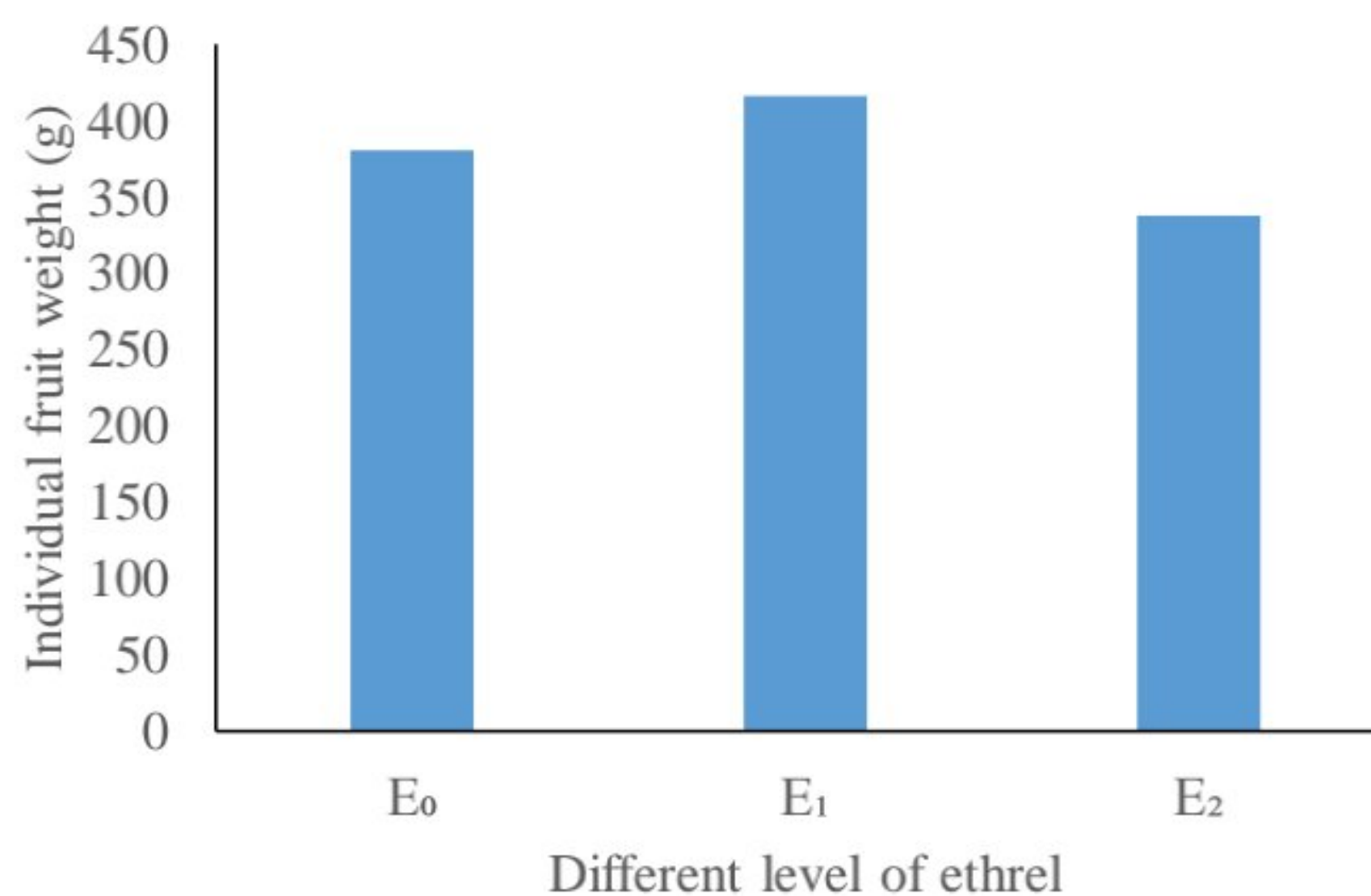


Fig. 17. Effect of ethrel on the individual fruit weight (g) of squash

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

Table 13. Interaction effects of variety and ethrel on the yield attributes of squash

Treatment combination	Individual fruit weight (g)	% dry matter of fruit (g)	Fruit weight (kg plant ⁻¹)	Yield (t ha ⁻¹)
V ₁ E ₀	445.08 b	6.27 bc	2.45 b	38.12 b
V ₁ E ₁	483.08 a	7.22 a	2.90 a	45.37 a
V ₁ E ₂	375.61 c	5.71 de	1.83 c	28.53 c
V ₂ E ₀	305.61 e	5.48 e	1.27 e	19.79 e
V ₂ E ₁	316.20 de	5.60 de	1.60 d	25.29 d
V ₂ E ₂	295.59 e	4.94 f	1.14 e	17.23 f
V ₃ E ₀	390.78 c	6.01 b-d	1.88 c	29.32 c
V ₃ E ₁	448.99 b	6.39 b	2.38 b	37.12 b
V ₃ E ₂	340.88 d	5.86 c-e	1.46 d	22.87 d
CV	5.60	4.65	4.87	5.02
LSD _(0.05)	30.857	0.478	0.158	2.544

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel

Table 14. Effect of variety on the yield attributes of squash

Varieties	% dry matter of fruit (g)	Fruit weight (kg plant ⁻¹)
V ₁	6.40 a	2.39 a
V ₂	5.34 c	1.34 c
V ₃	6.09 b	1.91 b
CV	4.65	4.87
LSD _(0.05)	0.276	0.091

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm

Table 15. Effect of ethrel on the yield attributes of squash

Ethrel	% dry matter of fruit (g)	Fruit weight kg plant ⁻¹
E ₀	5.92 b	1.87 b
E ₁	6.41 a	2.29 a
E ₂	5.50 c	1.48 c
CV	4.65	4.87
LSD _(0.05)	0.276	0.091

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima

E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm

4.2.12 Fruit yield plant⁻¹

A significant variation on the weight of fruits plant⁻¹ was experienced as influenced by different varieties (Appendix XI). The highest weight of fruits plant⁻¹ (2.29 kg) was found from the variety V₁ (GS-1) while the lowest weight (1.48 kg) was found from the variety V₂ (Cherub) (Table 14). Vadigeri *et al.* (2001) also observed differential response in fruit yield of cucumber varieties to ethrel concentrations.

The considerable influence was observed on the weight of fruits plant⁻¹ on account of different levels of ethrel (Appendix XI). The highest weight of fruits plant⁻¹ (2.29 kg) was found from E₁ (250 ppm ethrel) which was significantly different from all other treatments where the lowest weight of fruits plant⁻¹ (1.48 kg) was found from E₂ (500 ppm ethrel) (Table 15).

Remarkable variation was identified for the weight of fruits plant⁻¹ due to the interaction effect of variety and ethrel (Appendix XI). The highest weight of fruits plant⁻¹ (2.90 kg) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) where the lowest weight of fruits plant⁻¹ (1.14 kg) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) which was statistically similar with V₂E₀.

4.2.13 Fruit yield ha⁻¹

Significant variation was noted for the fruit yield ha⁻¹ as influenced by different varieties (Table 8 and Appendix XI). The highest fruit yield ha⁻¹ (37.34 t) was found from the variety V₁ (GS-1). In contrast, the lowest fruit yield ha⁻¹ (20.77 t) was found from the variety V₂ (Cherub) (Fig. 18).

The recorded data on fruit yield ha⁻¹ exerted significant effect with the application of different levels of ethrel (Appendix XI). The highest fruit yield ha⁻¹ (35.93 t) was found from E₁ (250 ppm ethrel) which was significantly

different from all other treatments (Fig. 19). The lowest fruit yield ha^{-1} (22.88 t) was found from E₂ (500 ppm ethrel). The increase in yield was predominantly due to the increased number of fruits and was also linked to increase in the fruit diameter and average fruit weight. The increase in yield may be attributed to the fact that plant growth regulators are involved in all aspects of growth and differentiation and, therefore, might have played a key role in sink strength as suggested by Patrick (1982) and Wyse *et al.* (1980). Similarly, Singh and Choudhary (1989) found beneficial effects of this chemical at particular concentration to an increased rate of photosynthetic activity and accelerated translocation. The increase in number of fruits twice and fruit yield thrice than control by application of cucumber seedlings with ethrel at 100-150 ppm, twice fruit yield of cucumber than control at 50-100 ppm ethrel by Rafeekher *et al.* (2001) and significant increase in number of fruits with ethrel at 400 ppm by Vadigeri *et al.* (2001) was also reported in the present investigation. Thomas (2008) also reported the effective role of ethrel in modifying sex than GA3 both in term of pistillate flower induction as well as percentage pistillate flowers developing into fruits.

Significant influence was noted on the fruit yield ha^{-1} as affected by the interaction effect of variety and ethrel (Appendix XI). The highest fruit yield ha^{-1} (45.37 t) was found from V₁E₁ (variety GS-1 with 250 ppm ethrel) which was significantly different from all other treatment combinations (Table 13). Oppositely, the lowest fruit yield ha^{-1} (17.23 t) was found from the combination V₂E₂ (variety Cherub with 500 ppm ethrel).

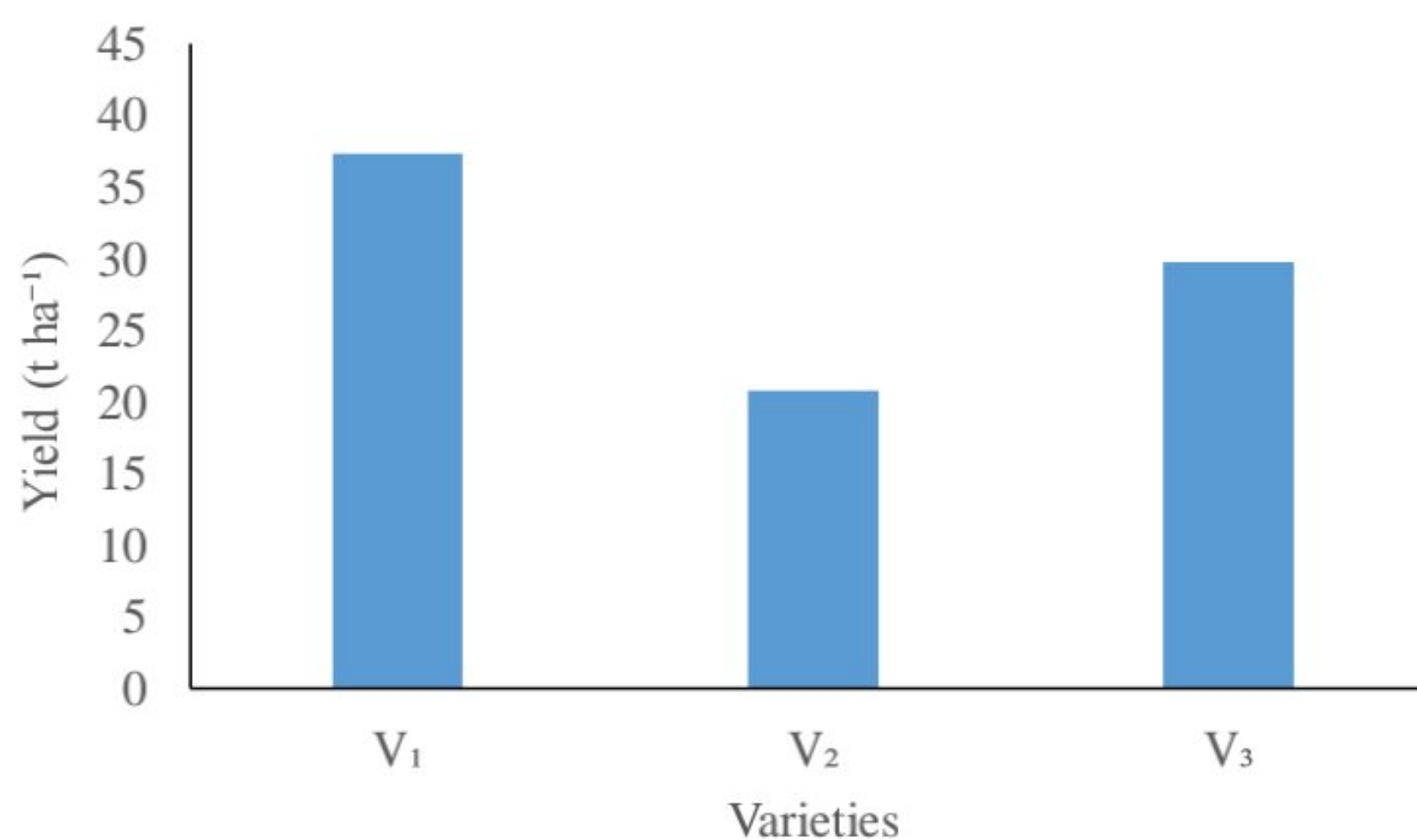


Fig. 18. Effect of variety on the fruit yield (t ha⁻¹) of squash

Vertical bar represented LSD at 0.05 level.

(V₁ = GS-1, V₂ = Cherub and V₃ = Cheonlima)

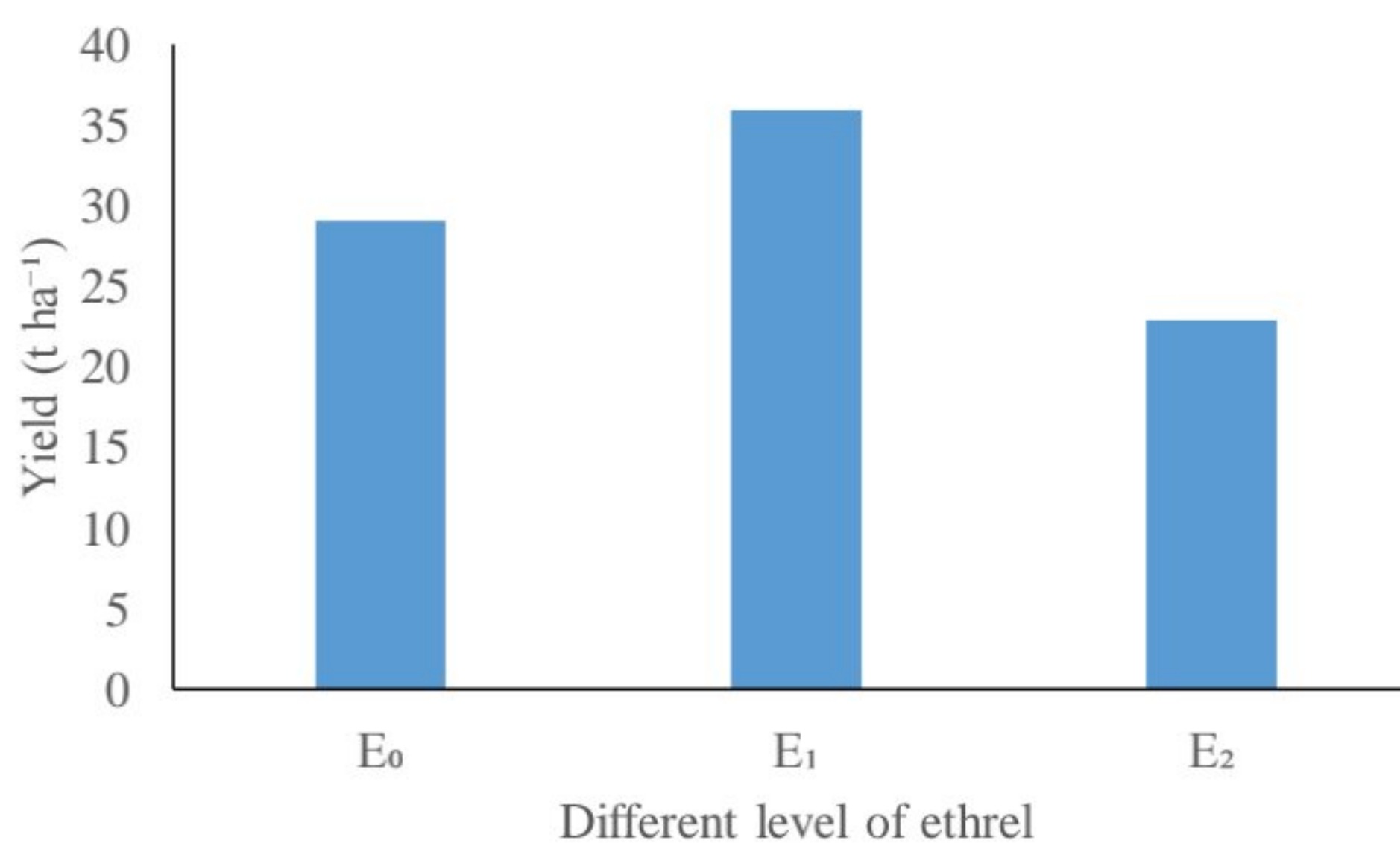


Fig. 19. Effect of ethrel on the fruit yield (t ha⁻¹) of squash

Vertical bar represented LSD at 0.05 level.

(E₀ = 0 ppm ethrel (control), E₁ = 250 ppm ethrel and E₂ = 500 ppm ethrel)

CHAPTER V

SUMMARY AND CONCLUSIONS

A field experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from October 2018 to March 2019 to study the effects of variety and different doses of ethrel on the growth and yield of squash. The experiment was consisted of two factors. Factor A: Varieties (three) i.e. V_1 = GS-1, V_2 = Cherub and V_3 = Cheonlima; Factor B: Different doses of ethrel (3 levels) i.e: E_0 = 0 ppm ethrel (control), E_1 = 250 ppm ethrel and E_2 = 500 ppm. There were in total nine (3 x 3) treatment combinations. The experiment was laid out in the Randomized Complete Block Design with three replications. Data were collected in respect of the squash growth characteristics and yield and yield contributing traits. The data obtained for different parameters were statistically analyzed to find out the significant difference and the means were separated using the LSD method.

Significant variation was observed in most of the studied traits as influenced by different varieties, levels of ethrel and their interactions. The highest (9.59, 23.10, 49.19, 55.53 cm at 15, 30, 45 DAT and at harvest) were found from the variety V_1 (GS-1) and the lowest plant heights (7.11, 17.73, 38.34 and 42.73 cm at 15 , 30, 45 DAT and at harvest) were noted from the variety V_2 (Cherub). Treatment E_1 (250 ppm ethrel) produced the highest plant height (9.82, 24.02, 51.21, 56.97 cm at 15, 30, 45 DAT and at harvest) and treatment E_2 (500 ppm ethrel) produced the lowest plant height (7.08, 17.31, 37.38, 42.17 at 15 DAT, 30 DAT, 45 DAT and at harvest). The highest plant height (11.47, 27.07, 56.98 and 63.77 cm at 15 , 30 , 45 DAT and at harvest, respectively) were found from the combination V_1E_1 (variety GS-1 with 250 ppm ethrel) and the lowest plant height (5.76, 14.24, 31.30 and 34.62 cm at 15, 30, 45 DAT and at harvest, respectively) were found from the combination V_2E_2 (variety Cherub with 500 ppm ethrel).

The highest number of leaves plant⁻¹ was found from the variety V₁ (GS-1) while the lowest was found from the variety V₂ (Cherub). The highest number of leaves plant⁻¹ was found from the treatment E₁ (250 ppm ethrel) and the lowest was found from the treatment E₂ (500 ppm ethrel). The highest number of leaves plant⁻¹ (9.11, 17.52, 24.53 and 27.33 at 15, 30, 45 DAT and at harvest, respectively) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) and the lowest was (5.67, 10.79, 15.10 and 16.82 at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel).

The highest leaf length and breadth was found from the variety V₁ (GS-1) and the lowest was found from the variety V₂ (Cherub). The highest leaf length and breadth was found from the treatment E₁ (250 ppm ethrel) and the lowest was found from the treatment E₂ (500 ppm ethrel). The highest leaf length and breadth (14.67, 36.80, 38.72, 43.54 cm and 16.80, 31.81, 35.50 and 37.00 cm at 15 DAT, 30 DAT, 45 DAT and at harvest, respectively) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) and the lowest leaf length and breadth (10.13, 21.71, 23.16 and 25.69 and 9.17, 19.04, 21.15 and 22.15 at 15, 30, 45 DAT and at harvest, respectively) were found from the combination of V₂E₂ (variety Cherub with 500 ppm ethrel) (Table 3).

The highest stem diameter was found from the variety V₁ (GS-1) while the lowest was found from the variety V₂ (Cherub). The highest stem diameter was found from the treatment E₁ (250 ppm ethrel) and lowest was found from the treatment E₂ (500 ppm ethrel). The highest stem base diameter (1.29, 1.71, 2.27 and 2.73 cm at 15, 30, 45 DAT and at harvest, respectively) were found from the combination V₁E₁ (variety GS-1 with 250 ppm ethrel) where the lowest (0.80, 1.13, 1.41 and 1.69 cm at 15, 30, 45 DAT and at harvest, respectively) were found from the combination V₂E₂ (variety Cherub with 500 ppm ethrel).

The least days for 1st male flowering, 1st female flowering, 50% male flowering and 50% female flowering (10.42, 12.61, 20.83 and 23.02) were recorded from the variety V₁ (GS-1) which was significantly different from all other treatments (Table 6). The highest number of days (14.4, 17.46, 28.86 and 31.89) were found from the variety V₂ (Cherub). The least days for 1st male flowering, 1st female flowering, 50% male flowering and 50% female flowering (10.17, 12.20, 20.34 and 22.47) were noted from the treatment E₁ (250 ppm ethrel) and the maximum days (13.90, 16.82, 27.80 and 30.83) was found from the treatment E₂ (500 ppm ethrel). The least days for 1st male flowering, 1st female flowering, 50% male flowering and 50% female flowering (9.26, 11.21, 18.53 and 20.47) was found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) and the maximum days (16.67, 20.28, 33.52 and 37.04) were noted from the combination V₂E₂ (variety Cherub with 500 ppm ethrel).

The highest number of male and female flowers and fruits plant⁻¹ (9.52, 9.22 and 5.62) were recorded from the variety V₁ (GS-1) while the lowest (8.37, 7.48 and 4.26) were counted from the variety V₂ (Cherub). The highest number of male and female flowers and fruits plant⁻¹ (9.58, 9.41 and 5.62) were experienced from the treatment E₁ (250 ppm ethrel) while the lowest (7.89, 7.27 and 4.24) were found from the treatment E₂ (500 ppm ethrel). The highest number of male and female flower and fruits plant⁻¹ (10.92, 10.51 and 6.45) were found from the combination of V₁E₁ (variety GS-1 with 250 ppm ethrel) and the lowest (7.69, 6.47 and 3.54) was found from the combination V₂E₂ (variety Cherub with 500 ppm ethrel).

The highest fruit length and diameter (23.61 and 4.60 cm) were measured from the variety V₁ (GS-1) but the lowest (19.45 and 3.59 cm) were found from the variety V₂ (Cherub). The highest fruit length and diameter (21.13 and 4.70 cm) were measured from the treatment E₁ (250 ppm ethrel) while the lowest (19.24 and 3.60 cm) were noted from the treatment E₂ (500 ppm ethrel). The highest fruit length and diameter (26.26 and 5.16 cm) were measured from the combination V₁E₁ (variety GS-1 with 250 ppm ethrel) but the lowest fruit length (16.82 and 3.02 cm) were found from the combination V₂E₂ (variety Cherub with 500 ppm ethrel) (Table 12).

The highest individual fruit weight (434.59 g), % fruit dry matter (6.40%), weight of fruits plant⁻¹ (2.29 kg) and fruit yield (37.34 t ha⁻¹) were noted from the variety V₁ (GS-1) whereas the lowest individual fruit weight (305.80 g), % fruit dry matter (6.40%), weight of fruits plant⁻¹ (2.29 kg) and fruit yield (37.34 t ha⁻¹) were found from the variety V₂ (Cherub). The highest individual fruit weight (416.09 g), % fruit dry matter (6.41%), weight of fruits plant⁻¹ (2.29 kg) and fruit yield (37.34 t ha⁻¹), were found from the treatment E₁ (250 ppm ethrel) where the lowest individual fruit weight (337.36 g), % fruit dry matter (5.50%), weight of fruits plant⁻¹ (1.48 kg) and (22.88 (22.88 t) were found from the treatment E₂ (500 ppm ethrel). The highest individual fruit weight (483.08 g), (%) fruit dry matter (7.22%), weight of fruits plant⁻¹ (2.90 kg) and fruit yield ha⁻¹(45.37 t) were found from the combination V₁E₁ (variety GS-1 with 250 ppm ethrel) and the lowest individual fruit weight (295.59 g), % fruit dry matter (4.94%), weight of fruits plant⁻¹ (1.14 kg) and fruit yield ha⁻¹ (17.23 t) were recorded from the combination V₂E₂ (variety Cherub with 500 ppm ethrel).

Conclusions

1. In a nutshell, the present findings paved the path to conclude that the highest fruit yield (37.34 t ha^{-1}) was found from the variety V_1 (GS-1) among the three varieties. Among different ethrel concentrations, E_1 (250 ppm ethrel) gave the highest fruit yield (37.34 t ha^{-1}).
2. In interaction effect, the highest fruit yield ha^{-1} (45.37 t) was found from the combination of V_1E_1 (variety GS-1 with 250 ppm ethrel). The variety GS-1 with the application of ethrel ensured the higher yield.
3. The experiment was conducted in AEZ no. 28 for only one season. So, further such type of experiment may be conducted in different agro-ecological zones of Bangladesh for more confirmation.

CHAPTER VI

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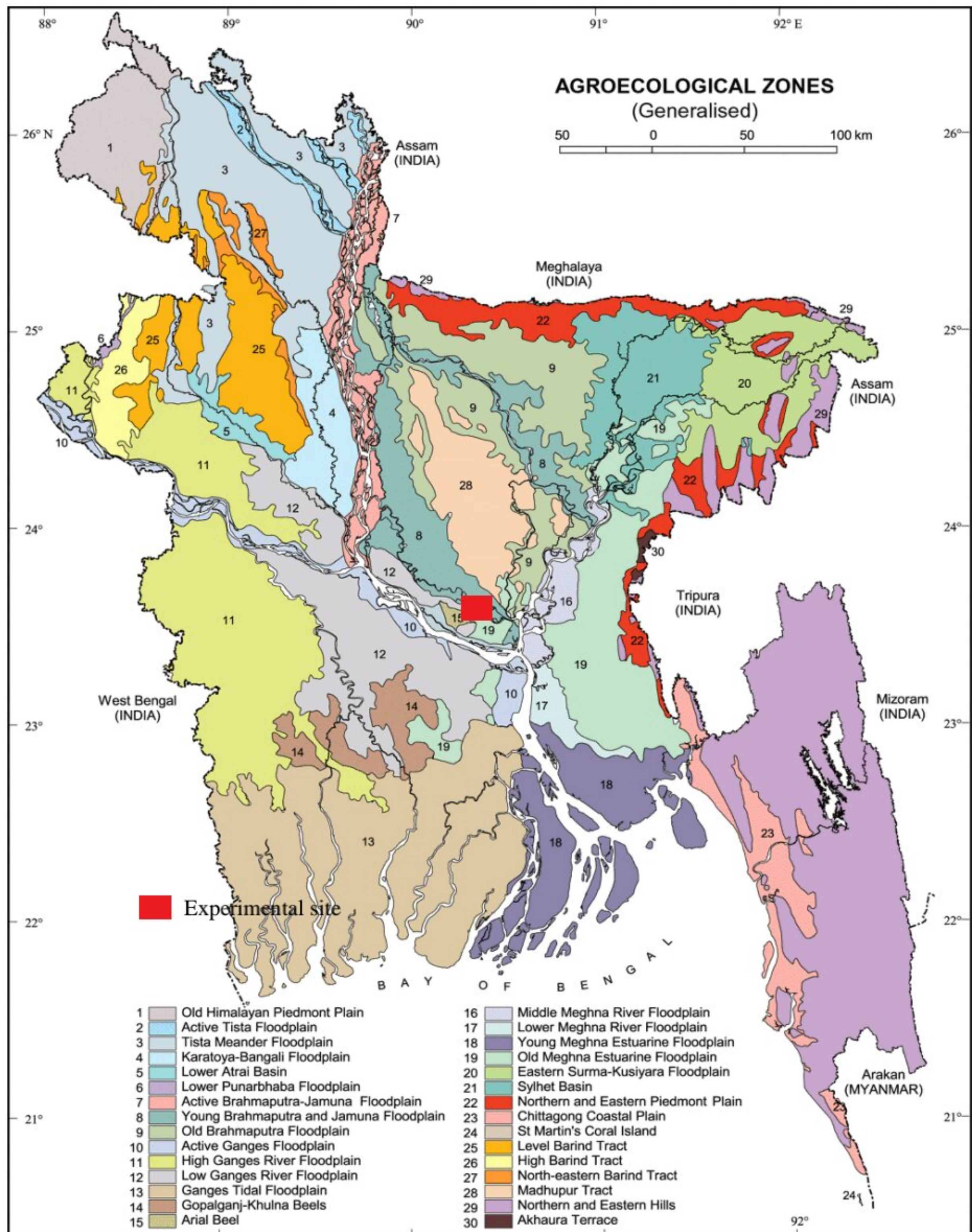
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APPENDICES

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



Appendix II. Monthly records of air temperature, relative humidity and rainfall from October 2018 to February 2019*

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max.	Min.	Mean		
2018	October	28.94	10.52	23.56	66.75	19.45
2018	November	28.62	8.52	18.56	56.75	14.40
2018	December	25.54	6.75	16.10	54.80	0.0
2019	January	23.82	11.74	17.75	46.20	0.0
2019	February	22.75	14.26	18.51	37.90	0.0

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

Appendix III. Characteristics of the experimental soil *

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture 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 Resources Development Institute (SRDI), Dhaka

B. Initial physical and chemical properties of the soil*

Characteristics	Value
Particle 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 Resources Development Institute (SRDI), Dhaka

Appendix IV. Analysis of variance (ANOVA) for the plant height of squash

Source of variance	Degree of freedom	Mean square of plant height (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	0.002 ^{NS}	0.48 ^{NS}	0.028 ^{NS}	0.87 ^{NS}
Varieties Factor (A)	2	13.85**	64.85**	265.32**	368.86**
Ethrel Factor (B)	2	17.65**	102.93**	436.72**	500.76**
A × B	4	0.52*	0.67*	5.11*	14.95*
Error	16	0.13	1.23	2.44	4.37
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix V. Analysis of variance (ANOVA) for the number of leaves of squash

Source of variation	Degree of freedom	Mean square of Number of leaves			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	0.04 ^{NS}	0.09 ^{NS}	0.02 ^{NS}	0.034 ^{NS}
Varieties (A)	2	5.11**	18.06**	37.96**	47.09**
Ethrel (B)	2	7.62**	30.75**	56.53**	70.16**
A × B	4	0.04 ^{NS}	2.21*	1.34*	1.41*
Error	16	0.34	1.67	0.81	1.69
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix VI. Analysis of variance (ANOVA) data on leaf length of squash

Source of variation	Degree of freedom	Mean square of Leaf length (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	0.017 ^{NS}	0.057 ^{NS}	0.064 ^{NS}	0.079 ^{NS}
Varieties (A)	2	14.34**	177.33**	177.24**	248.23**
Ethrel (B)	2	9.54**	74.30**	101.81**	103.92**
A × B	4	1.65**	2.36*	5.39*	6.90**
Error	16	0.29	1.79	2.04	2.50**
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix VII. Analysis of variance (ANOVA) for the leaf breadth of squash

Source of variation	Degree of freedom	Mean square of Leaf breadth (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	0.014 ^{NS}	0.087 ^{NS}	0.117 ^{NS}	0.116 ^{NS}
Varieties (A)	2	40.62**	63.82**	111.112**	86.306**
Ethrel (B)	2	16.77**	71.16**	68.150**	96.112**
A × B	4	2.05**	16.02**	29.363**	21.697**
Error	16	0.32	1.24	1.440	1.679
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix VIII. Analysis of variance (ANOVA) for the stem diameter of squash

Source of variation	Degree of freedom	Mean square of Stem diameter (cm)			
		15 DAT	30 DAT	45 DAT	At harvest
Replication	2	0.0001 ^{NS}	0.0012 ^{NS}	0.0002 ^{NS}	0.0004 ^{NS}
Varieties (A)	2	0.1072**	0.1536**	0.3214**	0.4728**
Ethrel (B)	2	0.1559**	0.2413**	0.4756**	0.6897**
A × B	4	0.0005 ^{NS}	0.0030*	0.0329*	0.0142*
Error	16	0.0023	0.0043	0.0069	0.0102
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix IX. Analysis of variance (ANOVA) for the flowering time of squash

Source of variation	Degree of freedom	Mean square of			
		Days for 1 st male flowering	Days for 1 st female flowering	Days for 50% 1 st male flowering	Days for 50% 1 st female flowering
Replication	2	0.054 ^{NS}	0.0811 ^{NS}	0.224 ^{NS}	0.242 ^{NS}
Varieties (A)	2	37.866**	55.378**	151.431**	183.956**
Ethrel (B)	2	31.983**	46.779**	127.791**	159.840**
A × B	4	2.339*	3.442*	9.385*	11.059*
Error	16	0.497	0.726	2.671	3.267
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix X. Analysis of variance (ANOVA) data on yield contributing characters of squash

Source of variation	Degree of freedom	Mean square of				
		Number of male flower	Number of female flower	Number of fruit plant ⁻¹	Fruit length (cm)	Fruit diameter (cm)
Replication	2	0.004 ^{NS}	0.005 ^{NS}	0.001 ^{NS}	0.005 ^{NS}	0.0381 ^{NS}
Varieties (A)	2	2.993**	6.961**	4.197**	2.633**	39.540**
Ethrel (B)	2	7.621**	10.395**	4.268**	2.794**	46.431**
A × B	4	1.726*	1.061*	1.182*	1.097*	3.760**
Error	16	0.176	0.149	0.052	0.051	1.000
Total	26					

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix XI. Analysis of variance (ANOVA) for the yield of squash

Source of variation	Degree of freedom	Mean square of			
		Individual fruit weight	% dry weight of fruit (g)	Fruit weight kg plant ⁻¹	Yield (t ha ⁻¹)
Replication	2	11.7 ^{NS}	0.006 ^{NS}	0.0001 ^{NS}	0.253 ^{NS}
Varieties (A)	2	38956.4**	2.673**	2.512**	619.21**
Ethrel (B)	2	13989.0**	1.834**	1.501**	383.63**
A × B	4	2011.4**	0.261*	0.085**	17.07**
Error	16	317.8	0.076	0.008	2.16
Total	26				

Here, ** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant



Plate 1. Photograph showing experimental field



Plate 2. Photograph showing fruit of variety GS-1



Plate 3. Photograph showing fruits of variety Cherub



Plate 4. Photograph showing fruits of variety Cheonlima