

**PERFORMANCE OF DIFFERENT HYBRID VARIETIES
OF TOMATO (*Lycopersicon esculentum* L.)**

A thesis

By

MD. SHAFIQUUL ISLAM

Student no. 1105072

Session: 2011-12

Thesis semester: January-June, 2013



**MASTER OF SCIENCE
IN
GENETICS AND PLANT BREEDING**

**DEPARTMENT OF GENETICS AND PLANT BREEDING
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY,
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ABSTRACT

Performance of six different hybrid tomatoes (*Lycopersicon esulentum*) namely BARI hybrid-4, Minto super, Delta, Minto, Unnayan and Tripti-2 with two check variety Ratan and Roma Vf (Popularly grown at chirirbandar, Dinajpur) were conducted in the Genetics and Plant Breeding research field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during November 2011 to April 2012. Ten characters were studied namely days to 50% flowering, plant height, fruit diameter, fruit length, individual fruit weight, canopy width, marketable fruits/plant, shelf life, thousand (1000) seed weight, yield/plant. A remarkable variation in plant characters and yield performance was noticed among the hybrids. The magnitudes of phenotypic co-efficient of variation were higher than corresponding genetic co-efficient of variation. Minto super was the highest yielding hybrid possessed highest individual fruit weight and plant height and second highest fruit diameter. The second highest yielding hybrid Delta possessed second highest fruit weight and plant height. It also produced moderate shelf life but longest days required for 50% flowering. The third highest yielding hybrid was BARI hybrid-4, which had highest number of marketable fruits per plant and better fruit weight, which contributed mainly to yield, compared to other hybrids and the check varieties. Yield of Minto super, Delta, BARI hybrid-4 is higher than the check varieties Ratan and Roma vf but only the hybrid variety Delta has higher shelf life with less variable fruit characters than two check varieties.

ABBREVIATIONS

BBS	:	Bangladesh Bureau of Statistics
cm	:	Centimeter
cv	:	Coefficient of variation
df	:	Degrees of freedom
FAO	:	Food and Agriculture Organization
GCV	:	Genotypic coefficient of variation
PCV	:	Phenotypic coefficient of variation
gm	:	Gram
K	:	Selection intensity
MSg	:	Mean sum of square of genotypes
MSe	:	Mean sum of square of error
r	:	Number of replication
σ^2_g	:	Genotypic variance
σ^2_p	:	Phenotypic variance
RCBD	:	Randomized Complete Block Design
CoV	:	Covariance

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CHAPTER I

INTRODUCTION



CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one the most important and popular winter vegetables of Bangladesh. It is the most consumable vegetable crop after potato and sweet potato occupying the top of the list of canned vegetable (Chowdhury, 1979). The tomato is the most widely used vegetable in the world and the highest economic value. It is widely used as raw or processed. It is used in diverse ways, including raw in salads and processed into ketchup or tomato soup. The tomato is mainly consumed fresh in salads, boiled or fried and in many forms of fresh vegetables used in curry. Various processed items viz. jam, jelly, ketchup, pickles, soups, pastes, sauces etc. are prepared from tomato. Unripe green tomatoes can also be breaded and fried, used to make salsa, or pickled. Though it is botanically a berry, a subset of fruit, the tomato is a vegetable for culinary purposes because of its savory flavor.

The name "tomato" came from the Nahuatt language of Mexico, and variants of this name have followed the crop in its spread throughout the world (Heiser, 1969). Tomato belongs to the family Solanaceae and genus *Lycopersicon*. The genus *Lycopersicon* is a Greek word; its means wolf's peach (Rashid 1976). The genus includes twelve species, all native to Latin America, and the Andean region. Among these species, only two have been recognize as edibles *L. esculentum*, the cultivated tomato and *L. pimpinellifolium*, a small fruited tomato called currant tomato (Choudhury, 1979). *L. esculentum*, the cultivated tomato was originated in Peruvian and Mexican Regions. It was introduced in into European countries by the Italians in the sixteenth century (McCue, 1952). It is believed that tomato was introduced into Indian sub-continent during the British regime.

Tomato is one the most popular fruit among millions of peoples in the orient. In Bangladesh it is considered to be one of the best of all the available vegetables. In fact, it will be no exaggeration to say that beautiful shades of color, delicious taste and high nutrition are the main reasons for its high popularity among the peoples of all

ages. It is a good source of vitamin C (31 mg per 100g), vitamin A, calcium, iron etc. (Matin et al., 1996). It is a rich source of ascorbic acid (Vit. C) and other vitamin such as Vit.A, thiamin (Vit-B₁), riboflavin (Vit-B₂) and niacin and minerals which keep our stomach and intestine in good condition. Its food value is rich because of higher contents of vitamins A, B and C, and calcium (Bose and Som, 1990). The chemical composition of tomato (approximate range): total sugar 2.50-4.50%, reducing sugar 1.50-3.50%, total solid 4.00-7.00%, Vitamin C 15.00-20.00mg/100g, Ca 0.25-0.50g/100g dry fruit weight, Mg 0.10-0.50 g/100g dry fruit weight, K 1.50-6.00/100 g dry fruit weight, Na 0.10-0.50g/100 g dry fruit weight, P 0.20-0.80g/100 g dry fruit weight, Fe 40-500 ppm fruit weight, Zn 10-50 ppm dry fruit weight, lycopene 20.00-50.00g dry fruit weight (Kalloo,1985).

The tomato is increasingly valued contain the carotene lycopene, one of the most powerful natural antioxidants. Lycopene is a carotenoid responsible for the color of ripe tomatoes. In some studies, lycopene, especially in cooked tomatoes, has been found to help prevent prostate cancer, improve the skin's ability to protect against harmful UV rays. A study done by researchers at Manchester and Newcastle universities revealed that tomato can protect against sunburn and help keeping the skin looking youthful. Recent studies have directly linked lycopene to the prevention of certain types of human cancer, particularly prostate cancer and with a lower incidence of heart disease such as arteriosclerosis (Mendoza, Andres Vasconcellos, 2000). Tomato consumption has been associated with decreased risk of breast cancer, head and neck cancers and might be strongly protective against neurodegenerative diseases. Tomato consumption might be beneficial for reducing cardiovascular risk associated with type 2 diabetes. The richest source of lycopene in the diet is tomato and tomato derived products.

Tomato is widely grown in Bangladesh usually in the winter season. The demand of tomato is increasing day after day in the agro and food industries of Bangladesh. Thus it has become an important cash crop in this country. Recent statistics showed that in Bangladesh tomato was grown in 18.8 thousand hectares of land and the average was 6.98 metric tons per hectare (BBS, 2008) which was very low compared to other

leading tomato producing countries of the world such as India (14.27 mt/ha), Japan (60.00 mt/ha), China (23.94 mt/ha), Egypt (35.08 mt/ha), USA (62.50 mt/ha) and Turkey (42.39 my/ha) (FAO, 2003). The total production is insufficient to satisfy the total demand of the country.

Tomato plants are indeterminate to determinate, growing erect to trailing type, pubescent to glandular, mostly annual. The leaves are 10–25 centimeters (4–10 in) long, odd pinnate, with five to 9 leaflets on petioles, each leaflet up to 8 centimeters (3 in) long, with a serrated margin; both the stem and leaves are densely glandular-hairy, stalked, ovate or oblong, 5-7 cm long, acuminate; flowers about 5-20 per cluster, fruit berry, obate, round, oval, pear, plum, square, round and in many other shapes, green, yellow to red in colour (Kalloo, 1985). On the basis of growth habit and flower production, tomato plants have been grouped into three types viz. indeterminate, intermediate and determinate.

Tomato thrives at widely extended latitudes and grows well under wide ranges of soil types, temperature and methods of cultivation (Ahmad, 1976). The cultivated tomato is very tender to cold and also rather intolerant of extremely hot or dry weather, a characteristic reflecting the nature of the climate in which it originated. In Bangladesh congenial atmosphere remains for tomato production during low temperature winter season that is early November is the best time for tomato planting in our country (Hossain et al., 1986). Tomato grows well in the areas where temperature ranges from 21-24⁰C in the monsoon (Krishnamurthy and Subramaian, 1954). The high temperature (both day and night), humidity, rainfall and light intensity are the basic limiting factors of tomato production (Abdulla and Verkerk, 1968). High day and night temperature above 32⁰C and 21⁰C respectively, was reported as a limiting factor to fruit set due to impaired complex of physiological process in the pistil, which results in floral or fruit abscission (Picken, 1984). For fruit setting favorable temperature is around 21⁰C. Night temperature is more important for fruit setting than that of the day. Such environment prevails during winter season in Bangladesh. But, recently some summer varieties viz. BARI Hybrid- 3 and BARI hybrid-4 have been developed in Bangladesh.

Considerable work has been done in different countries resulting in the development of numerous varieties of tomato. But in Bangladesh very limited works on tomato breeding have been initiated. Only some screening works on the introduced materials have been done for general yield performance. It is very important to develop high yielding varieties of tomato with good quality and with wider adaptability to meet the increasing demand of this vegetable in our country. Active breeding programs are ongoing by individuals, universities, corporations, and organizations and different seed companies. Corporations including BARI, Lalteer seed, Supreme seed, ACI seed, Metal seed, Syngenta seed, Giant Agro Ltd., Namdhari seed Ltd., Brac seed etc. have breeding programs that attempt to improve production, size, shape, color, flavor, disease tolerance, pest tolerance, nutritional value, and numerous other traits.

In Northern part of Bangladesh there are many commercial tomato hybrids are available in the market. These hybrids supplied by different government organization *e.g.*, BARI, BADDC and different seed company *e.g.*, Lal Teer seed Ltd., Supreme seed Ltd, Brac seed, ACI Seed Ltd., Metal seed Ltd., Syngenta seed Ltd., Namdhari Malik Seeds, Giant Agro etc. But, one of the most tomato growing region in Bangladesh at Chirirbandar, Dinajpur the farmers are still cultivate the local variety Roma Vf. But still upto Noember 2012, there was no comparative study of the performance of these hybrids. The farmers of this region are in dilemma and are uncertain about the performance of hybrids which one is best hybrids for this region. The present study was done to find out the reason why the farmers not cultivate the tomato hybrids. Six commercial single cross tomato hybrids which are available in market and two popular varieties extensively grown in Northern part especially in Chirirbandar, Dinajpur as checks were chosen for the present study. The present investigation was carried on the following objectives:

1. To study the performance of different commercial tomato hybrids.
2. To determine the variation of tomato hybrids
3. To select the outstanding tomato hybrids.



CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most popular and widely grown vegetable crops in many countries in the world. A large number of research works and much attention have been emphasized by many researchers on various aspects (both quantity and quality) of tomato. The work is increasing every year to release new varieties of tomato specially from developed countries. In our country also, attempt is continued to develop new cultivars from exotic /advance lines. The most pertinent and available literatures concerning variability and performance of different characters done on tomato and reported elsewhere have been reviewed in character wise in this chapter.

2.1 Days to 50% Flowering

Days to 50% flowering is regarded as an important yield contributing character in tomato breeding. In Mymensingh condition, Biswas and Mallik (1989) studied flowering period of 18 promising tomato cultivars and reported a range of 66 to 82.67 days for 50% flowering. Srinivas (2001) were characterized the flowers of 188 exotic tomato germplasms evaluated in Andhra Pradesh, India, during 1997-98. He reported that the variability for days to 50% flowering was highest in SLASF accession.

Anupam *et al.* (2002) were assessed the Genetic variability, heritability and genetic advance for 11 traits in 30 tomato grown in Ranchi, Bihar, India. Significant variation was recorded for days to 50% flowering for all the tomato genotypes.

Lakshmi and Mani (2004) studied the Correlation, variation and path coefficients for 13 yield attributes were estimated in 19 tomato genotypes at Hawalbagh, Uttar Pradesh, India. Analysis of variance indicated sufficient amount of variability for days to 50% flowering among the genotypes and path coefficient analysis also indicated that days to 50% flowering showed the highest direct effects on yield.

Singh *et al.* (2004) conducted an experiment on 92 tomato genotypes for correlation and path coefficient analysis and they observed that days taken to 50% flowering

showed a highly significant and negative correlation with the number of fruits per cluster and fruit length.

2.2 Plant height

Plant height has been found to vary from variety to variety and also among different groups such as determinate, intermediate and indeterminate type. In an experiment with 20 varieties of tomato in Ghana, Nsowah (1970) observed significant differences between cultivars for plant height. In another experiment on the performance of 13 tomato cultivars in Ghana and found significant differences among the cultivars. Ghosh *et al.* (1995) and Nandpuri *et al.* (1974) reported a high degree of variation for plant height while a narrow range of variations for this trait was observed by Ahmed (1987).

In a performance trial of 17 varieties of tomato in the Agricultural Research Institutes' farm at Joydebpur, Hoque *et al.* (1975) reported that only 5 varieties namely; Oxheart, Sinkurihara, L-7, Marglobe and Bulgaria gave promising yield. They further stated that the plant of variety Oxheart were taller than those of the variety Bulgaria. However, the taller produced higher number of branches and fruits per plant. Sinkurihara produced large sized fruit, on an average produced 40155.46 kg/hectares.

Prasad and prasad (1977) and Sonone *et al.* (1986) studied variability in tomato and reported that high genotypic and phenotypic co-efficient of variation for Plant height. Phenotypic co-efficient of variations were higher than genotypic co-efficient of variations for plant height was reported by Malik (1985).

Sharma and Rastogi (1993) carried out an experiment on evaluation trial of some tomato cultivars, they found significant variation for plant height among the cultivars. Ghosh *et al.* (1995) also reported a high degree of variation for this trait.

Aditya (1995), Matin (2001) and Shravan *et al.* (2004) reported that significant variation for plant height. According to Aditya (1995) plant height ranged between 48.8 and 104.2 cm While Matin (2001) reported that it ranged between 70.7 and 103.8

cm. Aditya (1995) and Matin (2001) also reported that the phenotypic variance was relatively higher than genotypic variance for this trait. They again observed that genotypic co-efficient of variation was lower than phenotypic co-efficient of variation indicating influence of environment for expression of this character.

Anupam *et al.* (2002) were assessed Genetic variability, heritability and genetic advance for 11 traits in 30 tomatoes grown in Bihar, India. They observed that there were no significant variations for plant height.

In a field experiment conducted in Maharashtra, India during 1993, Gaikwad *et al.* (2002) observed that tomato cultivars Dhanashree, Bhagyashree, Kewalo, Jubilee, EC 232118, Sut and LA-1462 were crossed with cultivars Pusa Ruby, Roma and Punjab Chhuhara in a line x tester cross to determine the combining ability of the cultivars for crop yield and yield components. They observed that LA 1462 was the best combiner for plant height. Singh *et al.* (2002) evaluated in Pantnagar, Uttaranchal, India for study the variation among 92 tomato genotypes with regard to 13 characters during winter of 2000-01 and the analysis of variance revealed highly significant genetic variation for plant height.

Joshi *et al.* (2004) conducted an experiment in Himachal Pradesh, India on 37 tomato genotypes and reported that the genotype FT-5 produced the highest plant height. In the late summer season of 2000, Mishra *et al.* (2004) was conducted an experiment in Karnataka, India to investigate the economics and performance of leaf curl resistant tomato cultivars for the variety TLB 111, TLB 130 and TLB 182 and they reported that TLB 182 showed the highest plant height (81.83 cm).

Singh and Raj (2004) studied the variability and heritability in 10 diverse tomato genotypes (Punjab Chhuhara, Sel.7, Pusa Ruby, Shalimar II, Arka Vikas, Pusa Early Dwarf, Shalimar I, SKAU-KT-1, SKAU-KT-2 and Local) were carried out in Kargil, Jammu and Kashmir, India. A wide range of variability along with high estimates of genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were recorded for plant height.

In the southern Telangana Zone of Andhra Pradesh, India, Padma and Reddy (2006) performed a study to identify the best tomato hybrid combination suitable for this region during 1999-2001. They reported that Plant height was highest in F₁ hybrid L₁T₃ during both 2000 (87.1 cm) and 2001 (92.1 cm) seasons.

Nitu-Kumari *et al.* (2007) conducted an experiment in Kanpur, Uttar Pradesh, India to assess the genetic variability of tomato cultivars KS-16, Azad T-3, Angoorlata, KS-29 and KS-7 and reported that the highest genotypic coefficient of variation was observed for plant height.

2.3 Fruit Diameter

Singh *et al.* (2002) studied the variation among 92 tomato genotypes with regard to 13 characters was evaluated in Pantnagar, Uttaranchal, India and reported that moderate phenotypic coefficient variation was found in the fruit diameter trait. In another study conducted in Himachal Pradesh, India performance study 37 tomato genotypes, Joshi *et al.* (2004) reported that the genotype A-2 produced the highest fruit diameter.

Ghosh *et al.* (2010) studied the F₂ segregating generations of exotic tomato hybrids to measure variability, character association and path coefficient analysis. Analysis of variance for each trait showed significant differences among the genotypes. Very little differences were observed between phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) for the trait fruit diameter (pcv=17.10, gcv=14.92).

Tasisa *et al.* (2011) studied twenty three tomato (*Lycopersicon esculentum* Mill.) genotypes to estimate variability, heritability and genetic advance in fruit yield and yield components at Bako Agricultural Research Center (Western Ethiopia) and reported that higher values of phenotypic coefficients of variation and genotypic coefficients of variation were observed for fruit diameter.

Prema *et al.* (2011) studied the variability in yield and quality traits for Six cherry tomato genotypes in Bengaluru (Karnataka), India. The high PCV and GCV were observed for fruit diameter (cm). Maurya *et al.* (2011) conducted an experiment in Varanasi, India to assess the magnitude of genetic variability and character association in 20 genotypes of tomato. Path coefficient analysis revealed that number of fruits per plant had maximum direct effect towards fruit yield followed by fruit width/diameter.

2.4 Fruit Length

Singh *et al.* (2002) studied the variation among 92 tomato genotypes with regard to 13 characters were evaluated in Pantnagar, Uttaranchal and reported that the greatest phenotypic variation was recorded for fruit length.

Singh and Raj (2004) studied the variability in 10 diverse tomato genotypes in Punjab, India and reported that a wide range of variability along with high estimates of genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were recorded for fruit length.

Joshi *et al.* (2004) conducted an experiment in Solan, Himachal Pradesh, India, during 2000-01 on 37 tomato genotypes. They reported that the genotype FT-13 produced the highest fruit length. Kumari *et al.* (2007) reported that the mean performance of F_1 hybrids was lower than parents for Fruit length.

Ghosh *et al.* (2010) were studied the F_2 segregating generations of exotic tomato hybrids to measure variability, character association and path coefficient analysis. Very little differences were observed between phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) for the trait fruit length (pcv=17.14, gcv=14.84).

Maurya *et al.* (2011) studied the genetic variability and character association in 20 genotypes of tomato. They were observed a great extent of variability for fruit length. Prema *et al.* (2011) studied the variability, heritability and genetic advance for growth, yield and quality traits for six cherry tomato genotypes in Bengaluru (Karnataka), India. The high PCV and GCV were observed for fruit length (cm).

2.5 Number of Marketable Fruits per plant

As an important yield contributing character, variability for number of marketable fruits per plant is well documented by several workers. Nandpuri *et al.* (1977) studied variability of 46 Indian and exotic tomato varieties and found significant varietal variations in number of fruits per plant. Singh *et al.* (1977) studied the variability for yield related character in 23 genotypes of tomato and reported that phenotypic variation was quite large but genotypic variation was low. The genotypic and phenotypic co-efficient of variation indicated that selection may be made for number of fruits per plant.

Prasad and Prasad (1979) and Dudi *et al.* (1983) studied variability for number of fruits per plant. They observed highest values for number of fruits per plant was recorded in EC 32099, HS 102, HS 107 and Columbia respectively. Sonone *et al.* (1986) reported that high genotypic and phenotypic co-efficient of variations were estimated for fruits per plant.

Bhutani *et al.* (1989) performed a varietal trial of 84 genotypes and reported that Set-23, Growthens Globe, Punjab Chuhara, VSII-2, Pusa Red Plun and HS 102 were the best for number of fruits per plant. Maximum genotypic improvement would be possible by genetic variability for number of fruits suggested by Sidhu and Singh (1989) from their observation. A significant range of variation for number of fruits per plant among 11 varieties of tomato was reported Fatunla (1969).

Mallik (1985) reported that phenotypic co-efficient of variation was higher than genotypic co-efficient of variation for plant height. Islam and Khan (1991) reported significant variation for number of fruits per plant. Reddy and Reddy (1992) evaluated 139 tomato genotypes and estimated phenotypic and genotypic variance, phenotypic and genotypic co-efficient of variation. They also reported that considerable variation was observed for number of fruits per plant (4.0-296.5).

Sahu and Mishra (1995) and Das *et al.* (1998) reported a wide range of genotypic variation for number of fruits per plant. They also reported high genotypic variation

for number of fruits per plant. Agong *et al.* (2000) was carried out the Systematic genotypic analysis of Kenyan tomato both landraces and market cultivars to facilitating tomato improvement and reported that landraces on average produced more fruit per plant (90) but of a smaller size than the market cultivars (19). Thakur and Bhardwaj (2000) conducted a field experiment in Himachal Pradesh, India, tomato hybrids (Naveen, BSS-20 and Nutan) and reported that Naveen recorded the highest number marketable fruit yield .

Baena *et al.* (2003) conducted experiment for the Generation advance and selection of promising F₆ and F₇ lines of *Lycopersicon esculentum* types chonto and kite, using pedigree and mass (population or bulk) selection, and single seed descent (SSD) and they reported that SELFENO contributed the largest number of promising lines of type chonto selected in the F₇ (6/10) with number of fruit/plant (43).

In an study for the identification of best hybrid combination suitable for the southern Telangana Zone of Andhra Pradesh, India, Padma and Reddy (2006) reported that Significantly more number of fruits per plant was recorded in HYT-1 (64.7), HYTH-1 (63.5) and Gotya (46.8) in 2000, and in HYTH-1 (56.0) and HYT-1 (55.8) in 2001 which ultimately affected the fruit yield. The number of fruits per plant of L₁T₃ (47.9), L₉T₃ (47.5) and Gotya (47.2) were at par in 2001.

In an another field experiment conducted in Jammu, India for the genetic and performance study of yield and quality traits in tomato, Dar and Sharma (2011) reported that the higher values of Phenotypic Coefficient of Variation (PCV) were recorded for number of fruits per plant. Bernousi *et al.* (2011) studied the genetic diversity in 25 tomato genotypes were investigated in two years at North-west of Iran during 2006-2007 and they reported that Maximum variability were observed for number of fruit per plant .

2.6 Individual Fruit Weight

Dudi *et al.* (1983) stated that variation for individual fruit weight indicated considerable variability for this character. They also stated that genotypic co-efficient of variation was very high for weight of fruits in four tomato varieties namely EC 32099, HS 107 and Columbia respectively. Sonone *et al.* (1986) reported that genotypic and phenotypic variance was high for individual fruit weight in the study of genetic variability with 13 genetically diverse tomato lines.

Ahmed (1987) reported that a wide range of variation was observed for individual fruit weight among 4 genotypes of tomato. He also reported that genotypic co-efficient of variation was very high for individual fruit weight in four tomato varieties Namely EC32099, HS 102, HS 107 and Columbia respectively. Reddy and Reddy (1992) estimated phenotypic and genotypic variances, phenotypic and genotypic co-efficient of variation for individual fruit weight. There was a considerable amount of variation observed for the average individual fruit weight (1.25-158.87).

In an experiment at Bhubansewar in India there was a high genotypic co-efficient of variation in the 16 tomato lines of tomato grown during the winter season in 1986 reported by Sahu and Mishra(1995). Dudi *et al.* (1983), Pujari *et al.*(1995), Das *et al.*(1998), Phookan *et al.*(1998) and Kumar and Tewari (1999) also obtained similar results in their experiments with tomato. Aditya (1995) observed that analysis of variance showed highly significant mean squares due to variety for average fruit weight among the 44 varieties of tomato. Genotypic variance associated with genotypic co-efficient of variation were smaller than phenotypic variance and phenotypic co-efficient of variation respectively.

Singh *et al.* (1997) conducted a study of the genetic variability of 23 genotype of tomato and they reported that phenotypic variation was quite large but the genotypic variation was low. The phenotypic and genotypic co-efficient of variation indicated that selection may be made for fruit weight.

Brar *et al.* (1998) reported that varietal differences were significant among 20 cultivars of tomato for average fruit weight ranged between 24.1g to 76.6g. Matitn (2001) also reported the similar result for fruit weight in an experiment with 26 tomato genotypes.

Agong *et al.* (2000) was carried out the Systematic genotypic analysis of Kenyan tomato both landraces and market cultivars to facilitating tomato improvement and reported that market cultivars had a superior average fresh fruit weight of 56.5 g while the landraces registered on average 40.6 g.

Zorzoli (2000) reported that the means for fruit weight were 52.17 g, 0.94 g, 4.45 g and 6.41 g in Caimanta, LA722, the F₁ and in the F₃ generations, respectively. The F₃ family with the greatest values for fruit weight showed a fruit weight mean of 20.15 g and the smaller fruit weight was 2.81 g.

Joshi and Kohli (2003) were assessed the nature and magnitude of genetic analysis in 73 tomato genotypes and they reported that the average fruit weight (102.76 g) were highest in Cluster 5 and 3, respectively.

Hardevinder and Cheema (2004) studied the heritability, genetic parameters and genotype x environment interactions among yield and other characters in 19 tomato genotypes were conducted at Punjab in India during 2001-03 and they observed that fruit weight was maximum in LT-16A and LT-36 in November and February sown crops, respectively. In an experiment conducted at Uttar Pradesh in India genetic variability with 30 tomato genotypes, Shravan *et al.* (2004) reported significant differences for average fruit weight among the genotypes.

Peiris *et al.* (2005) studied an experiment to investigate the adaptability and performance of 10 tomato hybrids (Alamra, Ninja, S-901, Gorden, Pomodoro, Sonata-21, Mission 102, Red Boy, Heat Master and the local hybrid HF-01) were evaluated in Gannoruwa, Sri Lanka, during 2003-04. They reported that the mean weights of the fruits of Ninja, Heat Master and HF-101 were more than 100 g.

In southern Telangana Zone of Andhra Pradesh, India for the identification of best tomato hybrids, Padma and Reddy (2006) reported that Average fruit weight was highest in L₆T₁ (120.0 g) followed by HYTH-1 (80.0 g) and L₆T₃ (78.0 g) in 2000; and in L₆T₁ (126.0 g) followed by HYTH-1 (84.0 g) and L₆T₃ (78.5 g) in 2001.

Kim *et al.* (2007) were evaluated eleven cultivars of cocktail (Temptation, Compari, Aranca, 72-108RZ and Messina) and round tomatoes *Lycopersicon esculentum* (BS6205, Relaxxm Axxion, Tabare, Flexxa, and Brilliant) to compare growth, firmness and yield. The fruit weight of cocktail tomatoes ranged from 32 to 60 g, and that of round tomatoes was 92 to 127 g.

Ghosh *et al.* (2010) conducted a field experiment in F₂ segregating generations of exotic tomato hybrids were studied to measure variability, character association and path coefficient analysis and they reported that the mean individual fruit weight (77.73g).

Pradeepkuma *et al.* (2011) were evaluated Fifty-two tomato genotypes of diverse origin for yield, fruit quality and resistance to bacterial wilt in Wayanad, Kerala, India. They observed that Fruit weight exhibited a range of 1.40-115.00g. Dar and Sharma (2011) conducted a study in Jammu, India to investigate the yield and quality traits in tomato and reported that the higher values of Phenotypic Coefficient of Variation (PCV) were recorded for average fruit weight.

2.7 Shelf Life

An important trait defining fresh tomato marketability is fruit shelf life. Dennis *et al.* (1979) stated that it was possible to store green mature fruits cultivars (Sonato and Soatine) for up to 6 to 10 weeks at in control atmosphere storage (3% O₂, 5%CO₂ and 92% N₂) at 10⁰C 93-95 % RH. De Vos (1996) stated that temperature requirement of fruits for slow ripening depends upon the stage of maturity. For prolonged storage, green fruits at 15⁰C, orange green fruits at 10⁰C and red fruits at 8⁰C were kept. He

also stated that at 20°C the fruit quality was deteriorated and under very low temperature condition chilling injury was caused and such situation arose below 10°C.

Upasana and Bains (1988) studied the composition and pectolytic changes in cultivars cv Chhuhara and cv Kosri, at green, intermediate and red ripe stage. They found that lycopene content showed a spectacular increase in the red ripe stage.

Subburamu *et al.* (1990) stated that fruits of tomato (cv. Pusha Ruby) were harvested at 4 maturity stages viz. Mature green, Breaker, half ripe and red ripe and held under ambient condition to assess weight loss shelf life and change color. They observed that shelf life was longer (11.0-12.5 days) in fruits picked at the mature green stage, but their quality after storage was poor and fruits picked at the breaker stage were of better quality and had an acceptable shelf life (8.3-10.5 days).

Haiking and Baerdemaker (1990) reported that when tomato fruits were harvested at different stages and stored for 12 days in 20°C, water loss during storage was lower in unripe fruits than ripe fruits.

Kagan and Mizrahi (1993) showed that, in the long shelf life cultivar BR124, the first fruits on the truss exhibited long shelf life when picked at the stage when fruits 11 and 12 on the truss were red. However, later fruits on the truss did not develop properly.

In India, Anju-Kumari *et al.* (1993) reported that the shelf life for all tomato cultivars (Roma VF, Pusha, Sioux and Solangola) were the longest with harvesting at the mature green stage. Stern *et al.* (1994) reported that tomato fruit were harvested at table ripe, breaker and mature stages. They observed that generation of volatile compounds (which is related to physical changes) decreased significantly with storage and ripening temperature below 10°C.

In an experiment at Yalova in Turkey, Kaynas and Surmeli (1995) recorded that tomato fruits (cvs. Es-58, 11-2274, Tobol and Riogrande) exhibited a shelf life of 40 days at 12°C when stored at the green mature and breaker stages and pink fruits can be

held for 25-30 days at 8°C. They also stated that tomatoes at the light red and red stages can be held for 10-15 days at 8°C and for 10 days at 12°C.

Goojing *et al.* (1999) performed an experiment at Hangzhou in China and reported that after 3 weeks of storage at 15-20°C. The mature hard tomato fruits was found 78.2% rotting. But only 47.5% fruit rotting was found in fruits harvested at green mature stage. They also stated that fruit stored in polythene bag at 4°C showed less rots and greater commodity rate than those stored similarly but with their sepals remove or those stored in bags at 15-20°C in polythene covered baskets at 4°C.

At Mohonpur in India, Mallik *et al.* (1996) reported that tomato cultivars (Roma, Pusha-Ruby, Sioux and Solangola) at an ambient condition. Shelf life was increased by earlier harvesting being 10.9-13.5 days for mature green fruits and 3.5-5.1 days for red ripe fruit. Fruits of Roma Showed the lowest physiological weight loss (7.8-9.7% after 6 days) and longest shelf life (13.5days when harvested at green mature stage). They also said that fruits harvested at the breaker of half ripe stage exhibited good shelf life and keeping quality.

In the performance studied of Carolina Gold tomato hybrids at North Carolina in USA, Gardner (2000) observed that the Fruits ripen to a uniform bright yellowish-orange (t gene), are firm with good shelf life and are comparable in flavour with those of Mountain Gold.

Parvinder *et al.* (2002) evaluated 15 heat tolerant tomato cultivars in Ludhiana, Punjab, India for genetic variation in yield and quality parameters and they observed that TH-2312 had the highest total yield and longest shelf life of mature green fruits and Namdhari Summer Set recorded the longest shelf life of ripe red fruits. They also reported that large fruits had better shelf life than small fruits.

Batu (2003) stated that tomato fruits were harvested at the mature green and pink stages of maturity and held for 60 days at 15°C (mature green fruit) or 13°C (Pink fruit) under three different controlled atmosphere (CA) conditions (3.2%, 6.4%, or 9.1% CO₂.) combined in all cases with 5.5% O₂. Mature green fruit were then kept for

additional 10 days at 20⁰C to stimulate shelf life conditions. Control tomatoes showed significantly higher flavor scores and were sweeter and more acceptable than those exposed to long-term CA storage.

Joshi *et al.* (2004) conducted an experiment in Himachal Pradesh, India on 37 tomato genotypes. They reported that the genotype FT-5 produced the highest harvest duration and shelf life of fruits and also produced the highest coefficient of variation (genotypic and phenotypic) was observed for fruit shelf life.

TingTing *et al.* (2005) conducted an experiment in Qingdao, China on protected cultivation of Meilisha and reported that it has a shelf life of 15 days at room temperature (25⁰C), and is suitable for protected and open field cultivation.

Xu-Na *et.al.* (2005) conducted experiment on a newly developed tomato hybrid in Shenyang, china and reported that this hybrid is suitable for protected cultivation and shelf-life production.

Rodriguez *et al.* (2005) were investigate the recombination of the productive and fruit quality traits in the segregating generation of the hybrid between a cultivated variety of *Lycopersicon esculentum* homozygous for nor and the accession LA1385 of *L. esculentum* var. *cerasiforme* using multivariate statistical analysis. They observed that Shelf life was the most outstanding fruit trait to discriminate groups in the F₂.

GuoZhi *et. al.* (2007) conducted an experiment in Hangzhou; china reported that the fruits of Zheza-205 have a good storage quality, with a shelf life lasting up to 25 days at room temperature (25⁰C). Zheza 205 is suitable for protected cultivation. Prema *et al.* (2011) conducted an experiment in Bengaluru (Karnataka), India of Six cherry tomato genotypes to study the variability, heritability and genetic advance for growth, yield and quality traits and they recorded that the high PCV and GCV were observed for shelf life of fruit (days).

2.8 1000 Seed Weight

Rodrigues *et al.* (2001) conducted an experiment in Maharashtra, India during the kharif season on seed yield and quality of tomato hybrid Rajashree reported that the interaction between the growth regulator and flower truss sequence was significant vigour index and 1000 seed weight. They observed the greatest 1000 seed weight was 3.95 g.

2.9 Yield per Plant

Yield per plant is the main and desired output of an experiment. The researchers had done so many works on yield per plant. Avdeev (1974) studied the general combining ability of 200 tomato varieties and wild forms for many characters including the fruit yield per plant and found that a positive heterosis was most frequent for fruit yield in most of the hybrid combination. Sachan *et al.* (1982) performed an experiment with certain tomato genotypes at south Gujrat, India and reported significant differences among the genotypes for yield per plant.

Jamwal *et al.* (1984) studied F_1 hybrid vigour and combining ability in tomato for several characters and reported that the best hybrids were EC 6050 x Lalmani, EC122156 x Lalmani and EC121193 x Gola for yield per plant. Ahmed *et al.* (1988) studied six varieties and their 15 F_1 hybrids for yield per plant. Most hybrids showed the positive heterosis over the parent Earliana x Burpired was highest yielding hybrid.

Patil and Bojappa (1988) studied on heterosis as influenced by genetic diversity and combining ability and found that Pusa Ruby x Sweet 72 showed the highest fruit yield (3.83 kg/plant).

Mandal *et al.* (1989) derived information from data on 8 yield related characters in 10 diverse genotypes and their 17 F_1 hybrids and found that Pusa Early dwarf x KS₁ was the highest yielding hybrid.

Sonone *et al.* (1986) reported that genotypic and phenotypic variance were high for average yield per plant. Reddy and Reddy (1992) reported that considerable variations

for yield per plant in 139 tomato varieties. Pujari *et al.* (1995) and Ghosh *et al.* (1995) observed highest variation for yield per plant.

Aditya (1995) observed that highly significant differences for average yield per plant among 44 genotypes of tomato. She also reported that Phenotypic variance and phenotypic co-efficient variation were higher than genotypic variance and genotypic co-efficient of variation respectively.

Raijadhav *et al.* (1996) conducted an experiment with 10 pure lines of tomato crossed in a diallel fashion and marked heterosis over better parent was observed for the characters marketable fruits yield per plant. The most promising hybrid was L4139 x CL246-0-3-3-00 which recorded 100.16% heterosis over the better parent.

Singh *et al.* (1997) observed that phenotypic variation was quite higher than genotypic variation for this trait in 27 genotypes of tomato. Kumar and Tewari (1999) reported genotypic co-efficient of variation was higher for average yield per plant among 32 tomato genotypes.

Brar *et al.* (2000) were estimated the heritability, genetic advance, phenotypic and genotypic coefficients of variation among yield and its component characters in 186 genotypes of tomatoes and a high degree of variation was observed for the character total yield per plant.

Baishya *et al.* (2001) evaluated 36 hybrids and nine parental lines of tomato with regard to yield and yield components and reported that EC-4881 x EC-130204 had the highest significant variation was found for yield per plant. Matin (2001) reported that significant differences for yield per plant among the genotypes tested.

Rupa *et al.* (2001) were evaluated thirty tomato genotypes for stability under diverse environmental conditions in Uttaranchal, India. They reported cultivars Rupali and Pant T-3 were the only stable genotypes for marketable fruit yield per plant.

Srinivas (2001) were characterized and evaluated the flowers of 188 exotic tomato germplasms at Andhra Pradesh in India. The average fruit yield per plant was highest

in SEF and SLASF (2197g and 2115 g, respectively). The variability in yield was highest in HEF.

Arun-Joshi and Kohli (2003) were assessed the nature and magnitude of genetic analysis in 73 tomato genotypes and they reported that the mean fruit yield per plant (1034.64 g/plant) were highest in Cluster 5 and 3, respectively. In an another studied at Himachal Pradesh in India on 37 tomato genotypes, Arun-Joshi *et al.*(2004) reported highest significant variation and genotype FT-5 produced the highest yield per plant.

Lakshmi and Mani (2004) were estimates the variation and path coefficients for 13 yield attributes in 19 tomato genotypes at Uttar Pradesh in India and the genotypes VTG 9, VTG 5 and VTG 4 were the best for yield per plant.

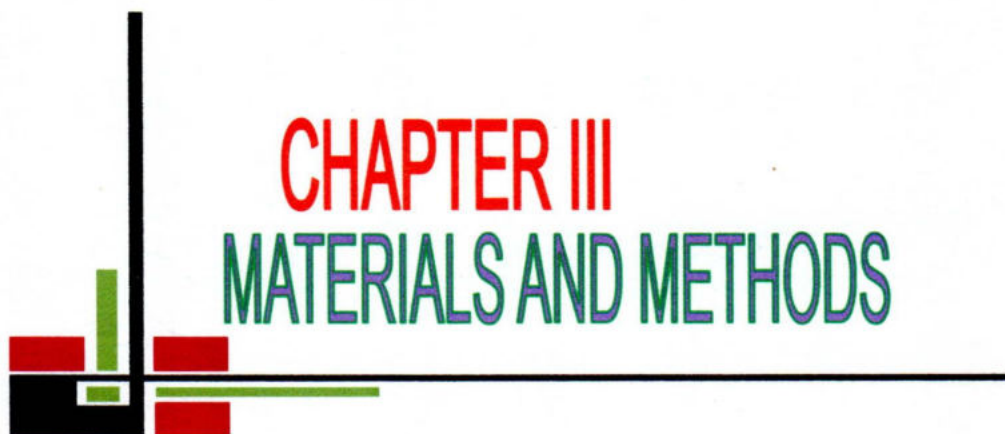
Peiris *et al.*(2005) performed a study on 10 tomato hybrids (Alamra, Ninja, S-901, Gorden, Pomodoro, Sonata-21, Mission 102, Red Boy, Heat Master and the local hybrid HF-01 at Gannoruwa in Sri Lanka. HF-101 had the highest yield (>50 t/ha) among the hybrids. Pomodoro and Alambra hybrids had very low yields. The relatively low yields of the exotic hybrids were due to bacterial wilt.

Pradeepkuma *et al.* (2011) were evaluated Fifty-two tomato genotypes of diverse origin for yield, fruit quality and resistance to bacterial wilt in Wayanad, Kerala, India. They observed a high degree of variation for yield per plant and exhibited a range of 80.00-2370.00g.



CHAPTER III

MATERIALS AND METHODS



CHAPTER III

MATERIALS AND METHODS

3.1 Description of the Experimental Site

The field experiment was conducted at the experimental field of the department of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from November 2011 to April 2012 to study the performance of different hybrid varieties of tomato. The soil belongs to the AEZ, Old Himalayan Piedmont soil.

3.1.1 Location

The experimental field was located at 25.13⁰ N latitude and 88.23⁰ E longitudes at an altitude of 37.5 m above from the mean sea level. The land belongs to the Old Himalayan Piedmont Plain Agro-ecological Zone (AEZ-1).

3.1.2 Soil

The land selected for the experiment was medium high land having sandy loam soil with P^H 5.6. The initial soil (0-15 cm depth) test revealed that the soil contained 0.10% total nitrogen, 1.06 organic matter, 24 (µg/g) available Phosphorus, 0.269 (meq /100g) available Potassium, 3.2 (µg/g) available sulphur and 0.27 (µg/g) boron. The characteristics of the soil were previously tested in the Soil Resource Development Institute (SRDI), Dinajpur.

3.1.3 Climate

The experimental area possesses sub-tropical climate. Usually the rainfall is heavy during Kharif season (March – September) and scanty in Rabi season (October – February). The atmospheric temperature was moderately low during Rabi season and increased as the seasons proceed towards Kharif season with occasional gusty winds. The weather condition such as monthly mean rainfall (mm), mean temperature (%), bright sunshine hours(day⁻¹) and humidity (%) are presented in Appendix iii (November- March) respectively .The mean of maximum temperature in summer.

3.2 Planting Materials

This study involved six tomato hybrids along with two varieties as check. The six hybrids used in this experiment were BARI Hybrid-4, Mintoo Super, Delta, Mintoo, Unnayan, and Tripti-2. These BARI Hybrid-4, Mintoo Super, Delta, Mintoo, Unnayan hybrid seeds were supplied from Lal Teer Seed Limited and Tripti-2 supplied from Brac seed. The two other popular varieties Ratan and Roma vf are collected from the commercial local tomato growers.

3.3 Experimental Layout

The experiment was laid out in a Randomized Complete Block Design with three replications. The individual plot size was 20m x 1m. Each replication contained 8 plots. Each plot contains 20 plants. The distances between the rows were 1m and plant to plant distances 1 m. There were 480 m² plots in this experiment. The seedlings were transplanted in the North-South direction.

3.4 Methods

3.4.1 Land Preparation

The experimental field was prepared thoroughly by ploughing and cross ploughing with tractor, power tiller and finally by country plough. Laddering was done to bring the soil to proper tilth and leveling. The weeds and debris were removed during land preparation.

3.4.2 Sowing and Transplanting

The seedlings were raised in the seedbed in usual way and 30 days old seedlings were transplanted in the experimental plot according to the experimental design on 26 December, 2011. Transplanting was done at afternoon and watering was done following transplanting for 7 days.

3.5 Intercultural Operations

When the seedlings were established, 1st mulching and weeding were done uniformly in all plots. Second weeding was done after 20 days of the first one. Mechanical

support was provided to the growing plants by bamboo sticks to them erect. During the early stages of growth pruning was done by removing some of the lateral branches to allow the plants to get more sunlight and to reduce the self –shading and incidence of increased insect infestation. During fruit development and maturity stage, another weeding was done for clean cultivation.

3.5.1 Gap filling

When the seedling was well established, the soil around the base of each seedling was pulverized. A few gap filling was done by healthy seedling of the same cultivar where initial planted seedlings failed to survive.

3.5.2 Irrigation

After transplanting of the seedlings were properly watered for 7 consecutive days .The flood irrigation was given to the plants after each top dressings of urea .Final irrigation was given during active fruiting stage.

3.5.3 Stalking and Pruning

When the plants were well established, stalking was done using Bamboo sticks. Sticks to keep the plant erect. Within a few days of stalking, as the plants grew up, the plants were the side shoots were removed.

3.6 Fertilizer Management

Manures and fertilizers were applied following standard recommendations as follows:

Name of the fertilizer/ Manures	Application rate (Kg/ha)
Cow dung	10000.00
Urea	270.00
Triple Super Phosphate(T.S.P.)	250.00
Murate of Potash (M.P)	150.00
Zinc Sulphate	5.00
Gypsum	50.00

Source: Bangladesher Shabji Chash, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur

At the time of land preparation, whole amount of decomposed cowdung, Triple Super Phosphate (T.S.P.), Murate of Potash (M.P.) and half amount of Urea were applied in the field. Rest amount of Urea were applied in two installments in equal quantity as ring placement method. The first ring placement was applied following 15 days of transplanting. The second installment was applied a week prior to flowering.

3.7 Plant Protection measures

Since the weather was favorable during the cropping period, there was no significant pest infestation in the field. In the month of February-March the due increasing of temperature some aphid infestation was occurred, due to this firstly Marshal and 3 days later Admire was applied in the field. Also some other vitamins Maflan were applied in the experimental plot.

3.8 Harvesting and Processing

Depending on variable maturity time harvesting continued for about one month because fruits of different hybrid varieties matured progressively at different dates and over long time. The fruits per entry were allowed to ripe and then seeds were separated from them and then the seeds were collected from them for future use.

3.9 Parameter Studied

Data on different yield and yield contributing characters were recorded on plot and plant basis as per experimental requirement. Data were recorded on the following crop characters;

- I. Days to 50% flowering
- II. Plant height(cm)
- III. Canopy width (cm)
- IV. Fruit Length (mm)
- V. Fruit diameter(mm)
- VI. Number of marketable fruits
- VII. Individual fruit weight (g)
- VIII. Shelf life
- IX. 1000 seeds weight (g)
- X. Yield per Plant (kg)

3.10 Data Collection

Data were recorded ten (10) randomly selected plants from each unit plot were selected randomly in a replication and were tagged individual plant. Out of ten Characters chosen for study days to 50% flowering, plant height, canopy width, fruit length, fruit diameter, number of marketable fruits, yield per plant were recorded in the field and the individual fruit weight, shelf life and 1000 seed weight were recorded in the laboratory after harvest. Criteria used in recording of data were as follows:

Plant height: The length of the main stem from the ground level to the tip, measured in centimeter at the time of first harvest.

Days to 50% flowering: Days to 50% flowering was determined by counting the number of days from transplanting of seedling up to appearing of 50% plants bearing flowers in the plot.

Length of Fruit: The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 selected marketable fruits from each plant of each replication and their average was calculated in centimeter.

Diameter of Fruit: Diameter of fruit was measured at the middle portion of ten selected marketable fruits from each cultivars of each replication with a slide calipers, and their average was calculated in centimeter.

Canopy width: The width of the canopy surrounding plant in ten randomly selected plants measured in centimeter at the time of first harvest.

Number of Marketable Fruits per Plant: Total number of matured and ripen marketable fruits harvested from each plant throughout the whole harvest period.

Individual Fruit Weight: Individual fruit weight was calculated in gram by dividing the total weight of fruits by the number of fruits per plant.

Shelf Life: The fruits were harvested from each replication of each variety and collected in the laboratory. Then wait for the days up to when the fruits were consumable treated as shelf life. The shelf life were calculated from the days of harvesting to the condition when it is unfit for consumption and marketing.

1000 Seed Weight: 1000 seed weight was considered as the cutting of each variety fruits per replication and the seeds were dried. Then 1000 seeds were counted and weighted.

Yield per Plant: Fruit yield per plant was recorded in kilogram at each harvest and added over all harvests to get the final yield per plant.

3.11 Analysis of Data

Data recorded for different parameters were compiled and tabulated in proper form of statistical analysis following RCB design to find out the statistical significance of the experimental results. The mean data of the genotypes from each plot were analyzed for Variance. To test the differences between genotypes Duncan's Multiple Range Test (DMRT) was performed by using MSTAT-C software.

3.11.1 Mean

On the basis of individual plant observations, the mean for each character in all the populations was computed as follows.

$$\bar{y} = \frac{1}{n} \left(\sum_{i=1}^n y_i \right)$$

Where,

$\bar{y}$ = Population mean

y_i = Individual value

n = Number of observations

3.11.2 Range

The minimum and maximum values on the basis of individual plant observations were used to indicate the range for a given character.

3.11.3 Variance

The means for all the treatment on the plot basis were estimated from the collected data and analysis of variance for each of the character under study was performed by F test (variance ratio). The mean difference were evaluated by Duncan's Multiple Range Test (Steel and Torric, 1960) for all the characters.

Variance was computed as follows.

$$\text{Variance} = \frac{1}{n} \left[\sum (y_i - \bar{y})^2 \right]$$

Where,

y_i = Individual value

$\bar{y}$ = Population mean

n = Number of observations

$$\text{Standard deviation (SD)} = \sqrt{\text{Variance}} = \sqrt{\sum d^2/n}$$

Where,

d = Deviation of individual value from mean

n = Number of observations

3.11.4 Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson *et al.* (1955).

$$\text{Genotypic variance } (\sigma^2_g) = \frac{MSg - MSe}{r}$$

Where, MSg = Mean sum of square of genotypes

MSe = Mean sum of square of error

r = Number of replications

$$\text{Phenotypic variance } (\sigma^2_p) = \sigma^2_g + \sigma^2_e$$

Where,

σ^2_g = Genotypic variance

σ^2_e = Error mean square

3.11.5 Estimation of genotypic and phenotypic co-efficient of variations

Genotypic and phenotypic co-efficient of variations were calculated according to the following formula given by Burton (1952), and Singh and Chaudhury (1985).

$$\text{Genotypic co-efficient of variation (GCV)} = \frac{\sqrt{\sigma^2_g}}{\bar{x}} \times 100$$

Where,

σ^2_g = Genotypic variance

$\bar{x}$ = Population mean

$$\text{Phenotypic co-efficient of variation (PCV)} = \frac{\sqrt{\sigma^2_p}}{\bar{x}} \times 100$$

Where,

σ^2_p = Phenotypic variance

$\bar{x}$ = Population mean

3.12 Uniformity Test

The raw data are to be used for the uniformity test by the SPSS software (11.5 Version) especially the boxplot. A boxplot is a statistical graph of continuous variable and in particular of the five number summary of a distribution and any outliers ("wild" values). The box represents 50% of ordered data stretching between the lower hinge and the upper hinge which represent the lower and upper quartile of the data respectively. The bar in this box indicates the median, which its position depicts the symmetry or skewness of the data. The boxplot displays the characteristics of the empirical distribution for single data at a glance: location, spread, skewness, tail lengths and outliers ("wild" values).



CHAPTER IV

RESULTS AND DISCUSSION



CHAPTER IV

RESULTS AND DISCUSSION

The Present study carried out with a view to determine the Performance of six tomato hybrids in respect to yield and yield contributing and some qualitative character. However, the results gave information of quite genetic nature about the hybrid used in this study. The results have been described and discussed under the following chapter. The interpretations on analysis of variance were presented first followed by differences among mean of all characters, genetic parameters of yield contributing characters on yield and the divergence of six tomato hybrid varieties.

4.1 Analysis of variance

The analysis of variance for the characters viz. days to 50% flowering, fruit diameter (mm), fruit length (mm), fruit weight (g), Plant height (cm), canopy width (cm), number of marketable fruits per plant, 1000 seed weight (g), Shelf life (days) and yield per plant of six tomato hybrids and two local and popular varieties of tomato as checks are presented in the table 1. The results of Duncan's Multiple Range Test (DMRT) are shown in the table-2 and table-3.

It was observed that mean sum of squares of the hybrids for all the characters were significant. Significant variation was observed among the varieties in all the characters. There was no significant variation found among the three blocks in all the characters. Coefficient of variation was low in Days to 50% flowering, 1000 seed weight, Fruit length, Fruit diameter and Plant height. Coefficient of variation in all the characters was equal to or less than 12.47 except individual fruit weight (25.95) due to time change as well as variation was found in the fruit size as a result CV was high in individual fruit weight. Different parameters of variability such as phenotypic variance and genotypic variances, genotypic and phenotypic co-efficient of variation etc. characters are shown in the table-4. The results of analysis of variance (Table-1) showed that the hybrids had significant differences among them for all the characters

indicating the existing genetic variance and there is a scope and chance for the selection of better hybrid varieties for cultivation to the farmer.

Table 1: Analysis of Variance of 10 important Characters of eight Tomato Varieties

Characters	Source of variation with mean Square			
	Replication (2 d.f.)	Genotype (7 d.f.)	Error (14 d.f.)	Co efficient of variation (%)
Days to 50% flowering	1.167	17.423**	1.262	2.48
Plant Height(cm)	163.104	336.723**	28.447	7.50
Fruit diameter(mm)	3.743	166.200**	5.010	4.48
Fruit length(mm)	20.583	84.945**	2.546	3.27
Fruit weight(g)	370.824	1082.898**	230.930	25.95
Canopy width (cm)	195.565	1015.091**	26.861	9.28
Number of marketable fruits per plant	48.746	184.769**	19.951	11.96
Shelf life (Days)	0.792	26.137**	0.601	7.24
1000 Seed Weight	0.003	0.380**	0.005	2.08
Yield per plant	.594	0.975**	0.064	12.47

Here, ** indicates significant at 1% level of probability and d.f. indicates degrees of freedom.

4.1.1 Days to 50% Flowering

Days to 50% flowering showed significant differences among the varieties studied in the experiment (Table 2). The mean value indicated that Delta took maximum days (48.0) to 50% flowering which was statistically identical with hybrids Mintoo Super, Mintoo and check varieties Ratan and Roma Vf. On the other hand, Unnayan required the minimum number of days to 50% flowering (40.67) which was similar with Tripti-2 (43.33). Georgieva (1969) reported, Pre-flowering period ranging from 56 to 76 days under his study. Sharma and Rastogi (1993) also observed significant variation for days to 50% flowering. In Mymensingh condition, Biswas and Mallik (1989) studied flowering period of 18 promising tomato cultivars and reported a range of 66 to 82.67 days for days to flowering.

The phenotypic variance (6.649) was comparatively higher than the genotypic variance (5.387) showing some environmental influence on this character. Phenotypic (5.703) and genotypic (5.134) co-efficient of variation were considerable variation (Table 4). From this result it is revealed that environmental effect for this character was high. Abedin (1981), Aditya((1995) and Matin (2001) also found the similar results.

Box plot showed the empirical distribution for the variation of days required for 50% flowering in six tomato hybrids and the two check varieties at glance. The Box plot was displayed hybrids e.g. BARI hybrid-4, Mintoo and Tripti-2 showed the least variation for days to 50% flowering which was similar to check varieties Ratan and Roma Vf. The hybrids Mintoo super, Unnayan and Delta showed the moderate variation for days to 50% flowering which was higher than the check varieties Ratan and Roma Vf.

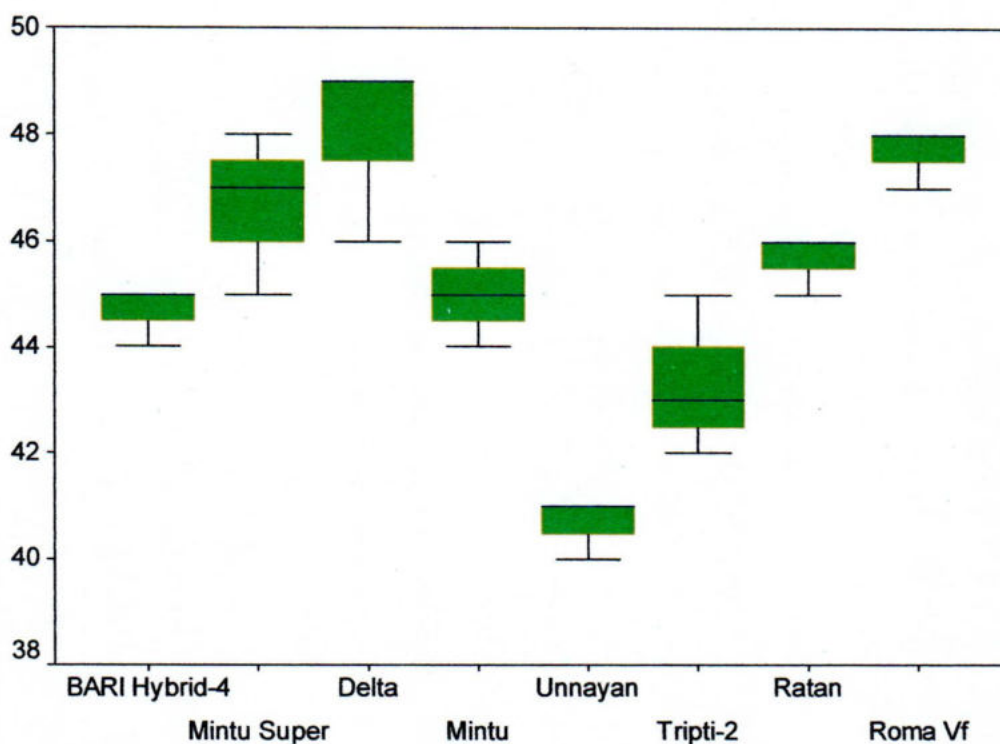


Fig. Box Plot for Days to 50% flowering of 8 tomato varieties

4.1.2 Plant height

Significant differences among the varieties were observed from the analysis of variance for plant height (Table 2). The significant varietal differences indicated a wide range of variation among hybrids and the check varieties for plant height with mean value ranged from 56.43 cm to 83.07 cm. The highest plant height was observed in the Mintoo Super (83.07) which was identical with hybrids BARI Hybrid-4 and Delta and check varieties Ratan and Roma Vf. The hybrid variety Mintoo was also identical with the check varieties Roma Vf and Ratan. The lowest plant height (56.43) was recorded in Tripti-2 which was similar with the hybrid Unnayan (Table 3). Nsowah (1970), Nandpuri *et al.* (1977), Sharma and Rastogi (1993) and Ghosh *et al.* (1995), Bineeth *et al.* (2004), Padma and Reddy (2006) and Nitu-Kumari *et al.* (2007) reported similar results for plant height.

Table 2: Mean Performance of ten important characters of 8 tomato varieties

Varieties	Plant weight (cm)	Days to 50% flowering	Fruit diameter (mm)	Fruit length (mm)	Fruit weight (g)
BARI Hybrid -4	78.33 a	44.67 bc	51.92 b	40.28 f	68.08 ab
Mintoo Super	83.07 a	46.67 ab	59.85 a	49.41 bcd	90.94 a
Delta	81.13 a	48.00 a	51.57 b	48.73 cd	72.80 ab
Mintoo	62.43 bcd	45.00 abc	47.30 bc	44.11 ef	43.58 ab
Unnayan	58.17 cd	40.67 d	40.02 d	55.97 a	40.90 b
Tripti-2	56.43 d	43.33 cd	43.62 cd	45.53 de	40.62 b
Ratan	73.23 abc	45.67 abc	60.38 a	52.68 abc	67.40 ab
Roma Vf	76.33 ab	47.67 ab	44.58 cd	53.91 ab	43.33 b
Grand mean	71.142	45.208	49.96	48.827	58.560
Mean LSD	9.340	1.967	3.920	2.794	26.613
Range	56.43-83.07	40.67-48.00	40.02-60.38	40.28-55.97	40.62-90.94

**Mean values having same letter did not differ significantly

Table 2: Mean Performance of ten important characters of 8 tomato varieties (Continued)

Varieties	Canopy width (cm)	Number of marketable fruits per plant	Shelf life (Days)	1000 Seed Weight	Yield per plant(kg)
BARI Hybrid - 4	75.23 a	53.97 a	10.0 cd	2.977 c	2.308 bc
Mintoo Super	69.73 ab	37.77 b	8.333 d	3.218 b	3.047 a
Delta	83.03 a	38.20 b	13.67 a	4.157 a	2.536 ab
Mintoo	39.87 c	41.17 ab	11.33 bc	3.217 b	1.685 cd
Unnayan	42.90 c	34.60 b	9.333 cd	3.160 bc	1.708 cd
Tripti-2	39.73 c	33.83 b	14.33 a	3.180 bc	1.287 d
Ratan	59.60 b	28.67 b	5.667e	3.352 b	2.007bcd
Roma Vf	36.77 c	30.70 b	13.00 ab	3.360 b	1.669 cd
Grand mean	55.858	37.363	10.708	3.327	2.031
Mean LSD	9.076	7.822	1.358	0.121	0.443
Range	36.77-83.03	28.67-53.97	5.667-14.33	2.977-4.157	1.287-3.047

Table 3: Genetic Parameters of ten important characters of eight tomato Varieties

Characters	Genotypic Variance (σ^2_g)	Phenotypic variance(σ^2_p)	GCV (%)	PCV (%)
Plant Height (cm)	102.759	131.205	14.248	16.100
Days to 50% flowering	5.387	6.649	5.134	5.703
Fruit diameter (mm)	53.73	58.74	14.687	15.356
Fruit length (mm)	27.466	30.012	10.733	11.219
Fruit weight (g)	283.989	514.919	28.772	38.479
Canopy width (cm)	329.41	356.271	32.492	33.788
Number of marketable fruits per plant	54.939	74.89	19.838	23.161
Shelf life (Days)	8.512	9.113	27.246	28.192
1000 Seed Weight	0.125	0.130	10.626	10.837
Yield per plant(kg)	0.304	0.368	27.147	29.868

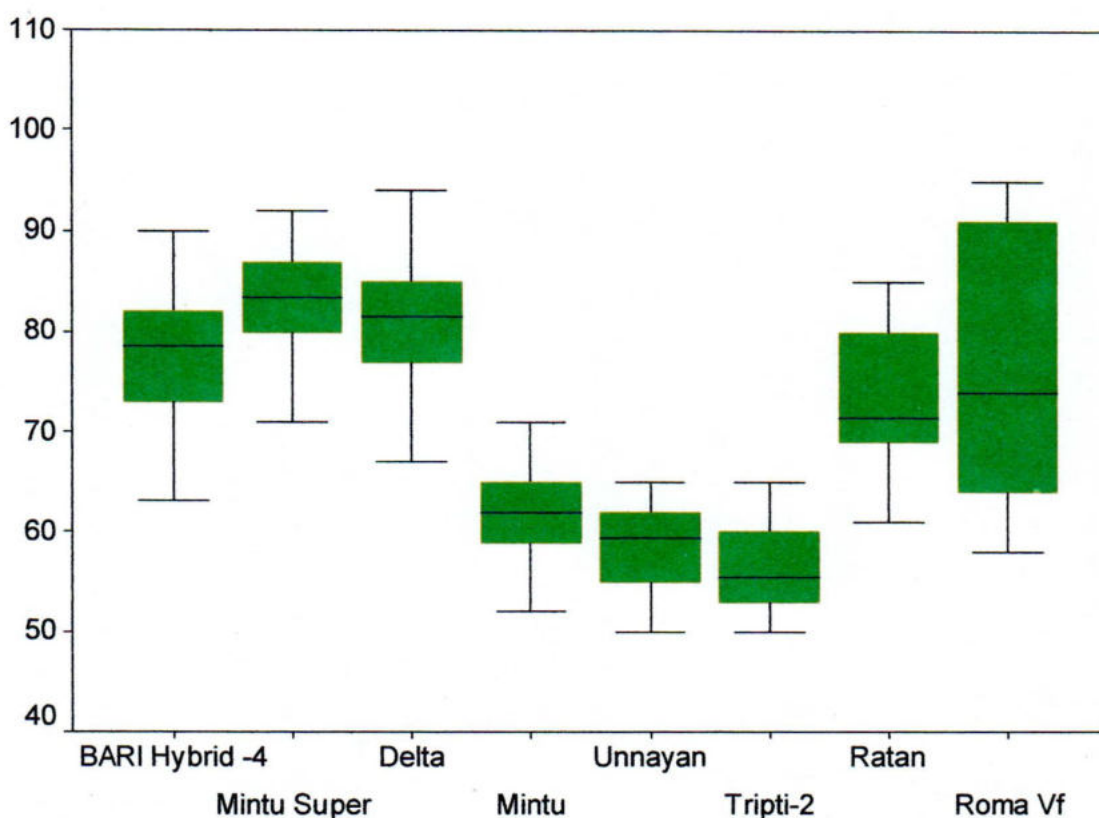


Fig. Boxplot for Plant Height of 8 tomato varieties

Phenotypic variance for this trait (131.205) is relatively higher than genotypic variance (table 4). The genotypic (14.248%) and phenotypic (16.1%) co-efficient of variation indicated a slight influence of environment for the expression of this character. Islam and Khan (1991) observed the highest genotypic and phenotypic co-efficient of variations (15.09% and 22.19%) for plant height in a study of tomato genotypes received from AVRDC, Taiwan grown at BARI farm, Joydebpur. Singh *et al.* (1993) and Singh and Raj (2004) also found high genotypic and phenotypic co-efficient of variation 22.4% and 23.7% respectively with 89.1% heritability for this character.

Box plot displayed the empirical distribution of plant height for six tomato hybrids and two check varieties. It showed that hybrids e.g. Mintoo, Mintoo Super and Tripti-2 showed least variation for plant height than the check varieties Ratan and Roma Vf. BARI hybrid-4, Delta and Unnayan showed moderate variation but less than the check

varieties Ratan and Roma Vf. However, the check variety Roma Vf showed the highest plant height but the variation among the plant and replication is higher than all other hybrids studied in this experiment.

4.1.3 Fruit Diameter

Fruit diameter is an important growth character of tomato plant. Fruit diameter was recorded at harvest. The variation in fruit diameter among the different varieties was found to statistically significant (Table 1). The check variety Ratan(60.38) produced the maximum fruit diameter which is identical with the hybrid Mintoo super. BARI hybrid-4(51.92), Delta (51.57) and Mintoo (47.30) produced the similar diameter which is smaller than the check Ratan and bigger than the check Roma Vf. Hybrid variety Mintoo, Tripti-2 and the check Roma Vf produced the identical fruit diameter and is smaller than the check Ratan(60.38). Unnayan(40.02) produced the lowest fruit diameter which was also similar to check Roma Vf. Arun –Joshi *et al.* (2004) and Tasisa *et al.*(2011) observed the similar result for fruit diameter.

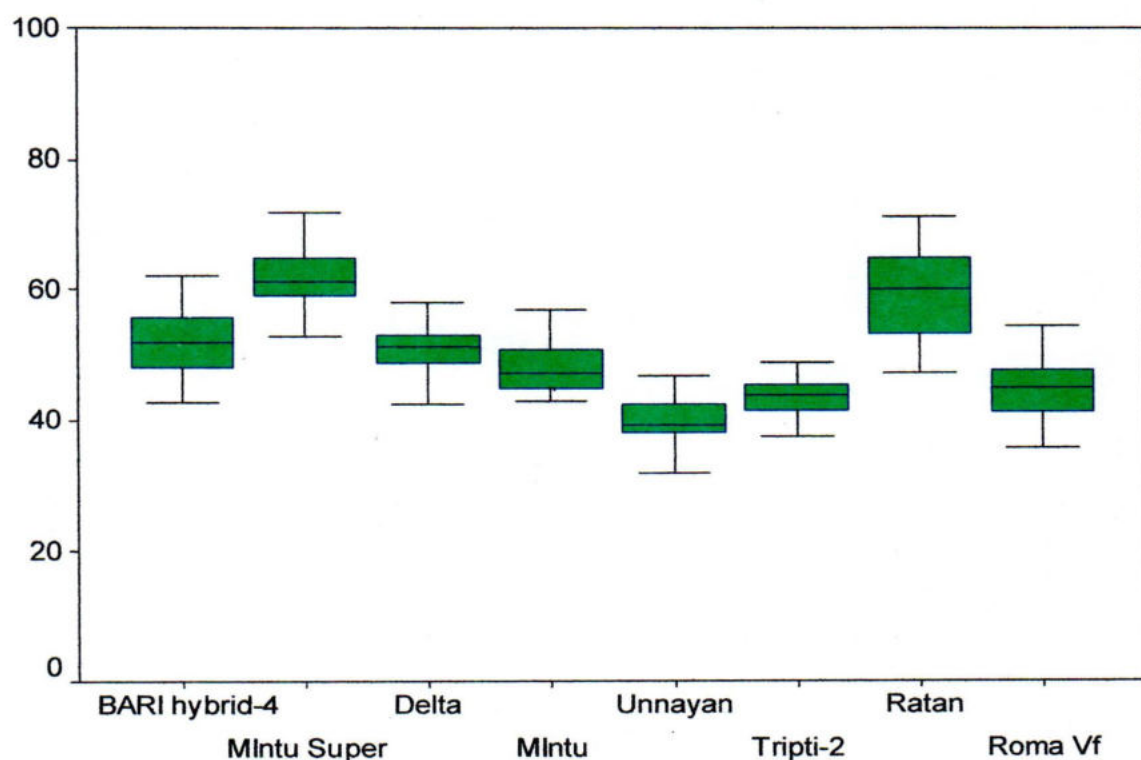


Fig. Box Plot for Fruit Diameter of 8 tomato varieties

Boxplot easily displayed the empirical distribution for the character fruit diameter. The boxplot showed that there were a less variation among all the hybrids and check varieties. Delta, Unnayan and Tripti-2 had the least variation in fruit diameter which was less than check varieties Ratan and Roma Vf. Mintoo super, BARI hybrid-4 and Mintoo showed the moderate variation which was similar to check variety Ratan but less variation than the check variety Roma Vf.

4.1.4 Fruit Length

Study on variation for fruit length indicated a considerable variation for this character. A wide range of variation was found among the hybrids and checks for the character fruit length and its ranges from 40.28 to 55.9. The hybrid Unnayan (55.97) produced maximum fruit length than other hybrids and check varieties which was identical with the check varieties Roma Vf (53.91) and Ratan (52.68). The hybrid Mintoo super (49.41) produced the fruit length which was similar to checks Ratan and Roma Vf. The hybrid Mintoo Super and Delta (48.73) produced fruit length which was no significant differences between them but smaller than the check Roma Vf (53.91). The lowest fruit length produced BARI hybrid-4 which was statistically insignificant with other hybrids *e.g.* Mintoo and Tripti-2 and smaller than check varieties Ratan and Roma Vf. Arun-Joshi *et al.* (2004), Nitu-Kumari *et al.* (2007) and Vyas-Maurya *et al.* (2011) reported the similar results for fruit length.

The boxplot showed that the hybrid Delta had least variation for fruit length than all other hybrids and check varieties. BARI hybrid-4, Mintoo, Unnayan and Tripti-2 showed slightly moderate variation which was less than the check varieties. The hybrid Mintoo super recorded moderate variation which was identical with checks Ratan and less than Roma Vf. The check variety Roma Vf showed the maximum variation for the character fruit length than all other hybrids and the check variety Ratan.

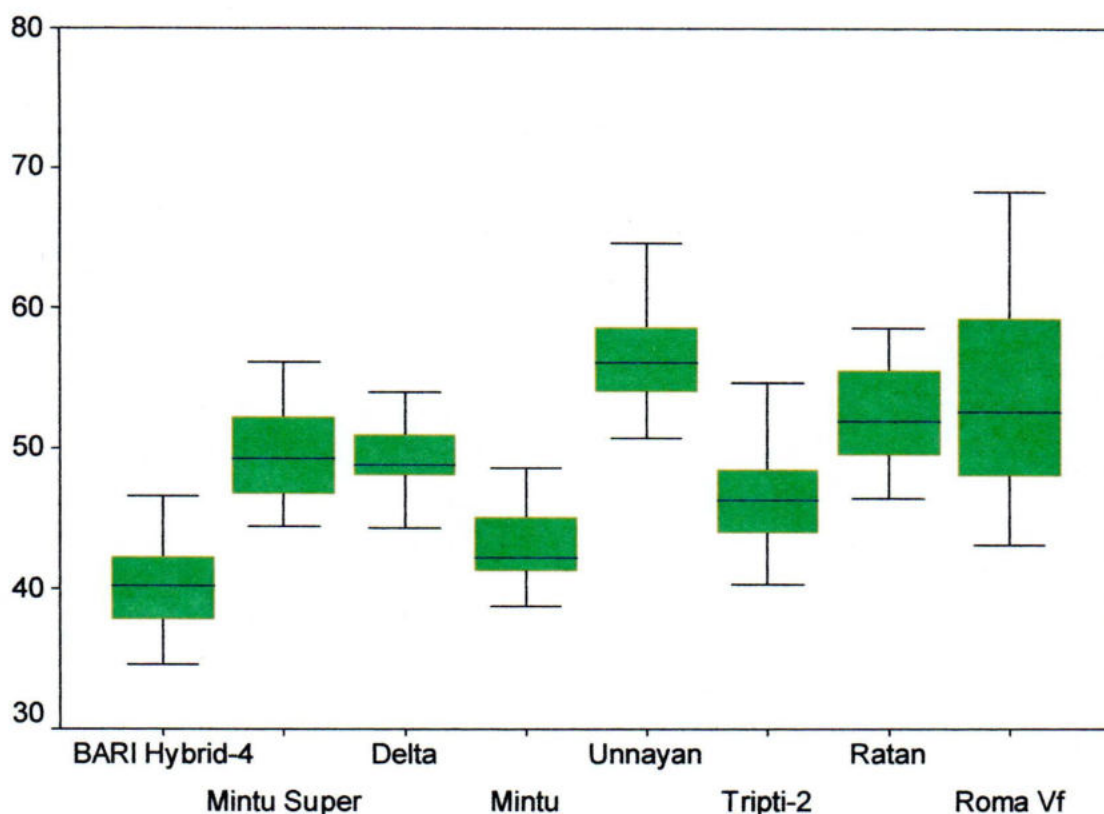


Fig. Box Plot for Fruit length of 8 tomato varieties

4.1.5 Canopy width

The study of variance for canopy width showed the highly significant variation among the hybrids and also checks varieties. The significant varietal differences indicated that there was a wide range of variation among the hybrids and the checks for canopy width with the mean values ranging from 36.77cm to 83.33cm (Table 2). The hybrid Delta (83.03cm) produced the largest canopy width which was identical with BARI hybrid-4 (75.03) and higher than the check varieties Ratan (59.60) and Roma Vf (36.77). The hybrid Mintoo super (69.73) produced canopy width which was similar to the check Ratan (59.60cm). The lowest canopy width produced check Roma Vf (36.77cm) which was identical with hybrids Tripti-2, Unnayan and Mintoo.

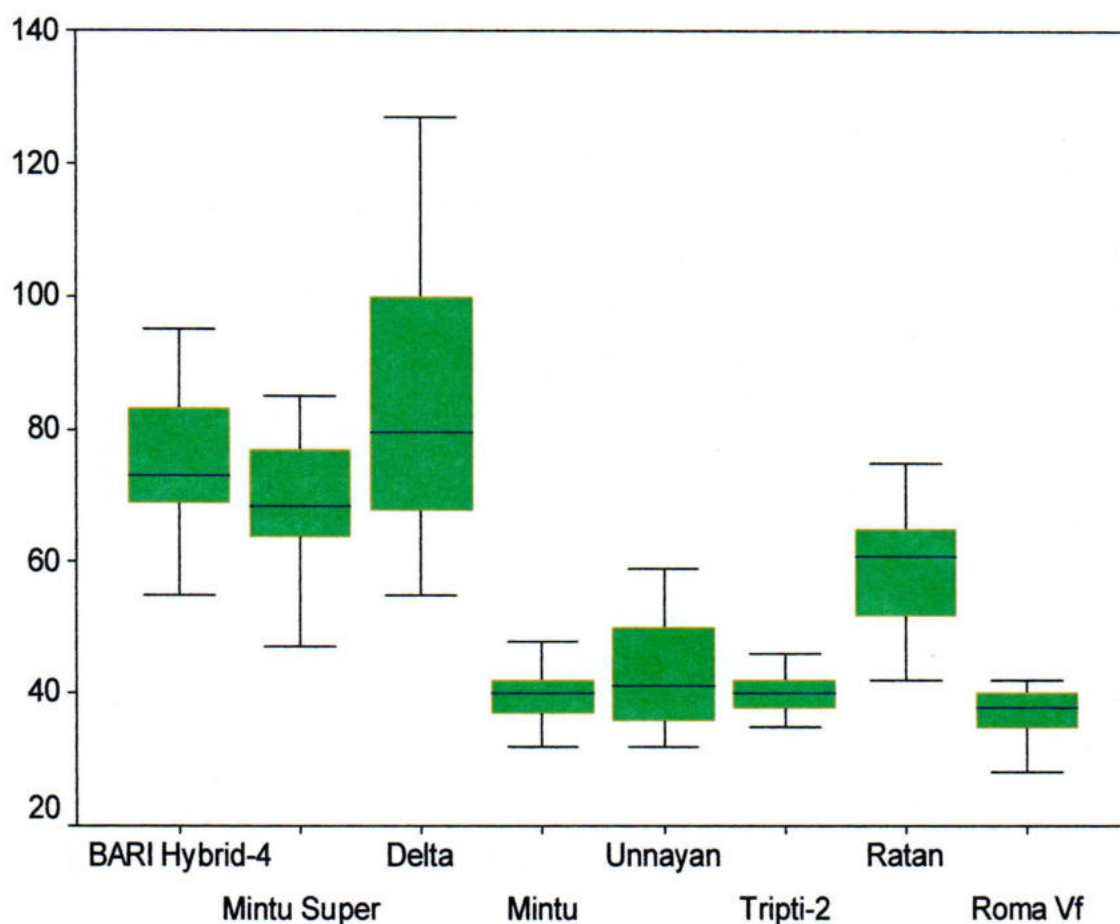


Fig. Box Plot for Canopy Width of 8 Tomato varieties

Boxplot displayed that the empirical distribution of the six tomato hybrids and the two checks for the character canopy width at a glance. The boxplot showed that hybrids Tripti-2, Mintoo and the check variety Roma Vf showed least variation for the wideness of canopy. Moderate variation was observed in Mintoo super, BARI hybrid-4 and Unnayan which was identical with the check variety Ratan but higher variation than the popular variety Roma Vf. Maximum variation in canopy width was found in the hybrid Delta which was significantly higher than all other hybrids and check varieties.

4.1.6 Number of Marketable fruits per Plant

There was a wide range of variation among the hybrids and the check varieties for the character number of marketable fruits per plant and the variability ranges from 28.67-53.97g (Table 2). Similar results were reported by Nandpuri et al. (1977), Bhutani et al. (1983), Aditya (1995) Martin (2001), Padma and Reddy (2006), Baena *et al* (2003) and Bernousi *et al.*(2011).BARI Hybrid -4 produced highest number of marketable fruits per plant(53.97) which is identical with hybrid Mintoo. There were no significant differences among the varieties BARI hybrid-4 and Mintoo. Again the lowest number of fruits per plant was produced by the check Ratan(28.6).The hybrids Mintoo super (37.77), Delta(38.20), Unnayan (34.60), Tripti-2 and check varieties Roma Vf produced the similar number of marketable fruits per plant as produced Ratan and no significant differences among them. Number of marketable fruits per plant showed a wide range of variation from 28.67 to 53.97.

The phenotypic variance (74.89) was considerably higher than the genotypic variance (54.939) indicating moderate influence of environment for this character. There is also significant difference between the phenotypic co-efficient of variation (23.161) and genotypic co-efficient (19.838). Similar results were reported by Prasad and Prasad (1977), Dudi *et al.*(1983), Sonene *et al.*(1986) , Reddy and Reddy (1992) , Singh *et al.* (1998), Brar *et al.*(2000).

The hybrid Delta, Unnayan and Tripti-2 showed the minimum variation which was similar to the check variety Ratan but less variation than the check variety Roma Vf for the number of marketable fruits production. Mintoo super and Mintoo showed the moderate variation which was identical with the check varieties Roma Vf. The BARI released variety BARI hybrid-4 had the maximum variation for number of marketable fruits production than check varieties Ratan and Roma Vf.

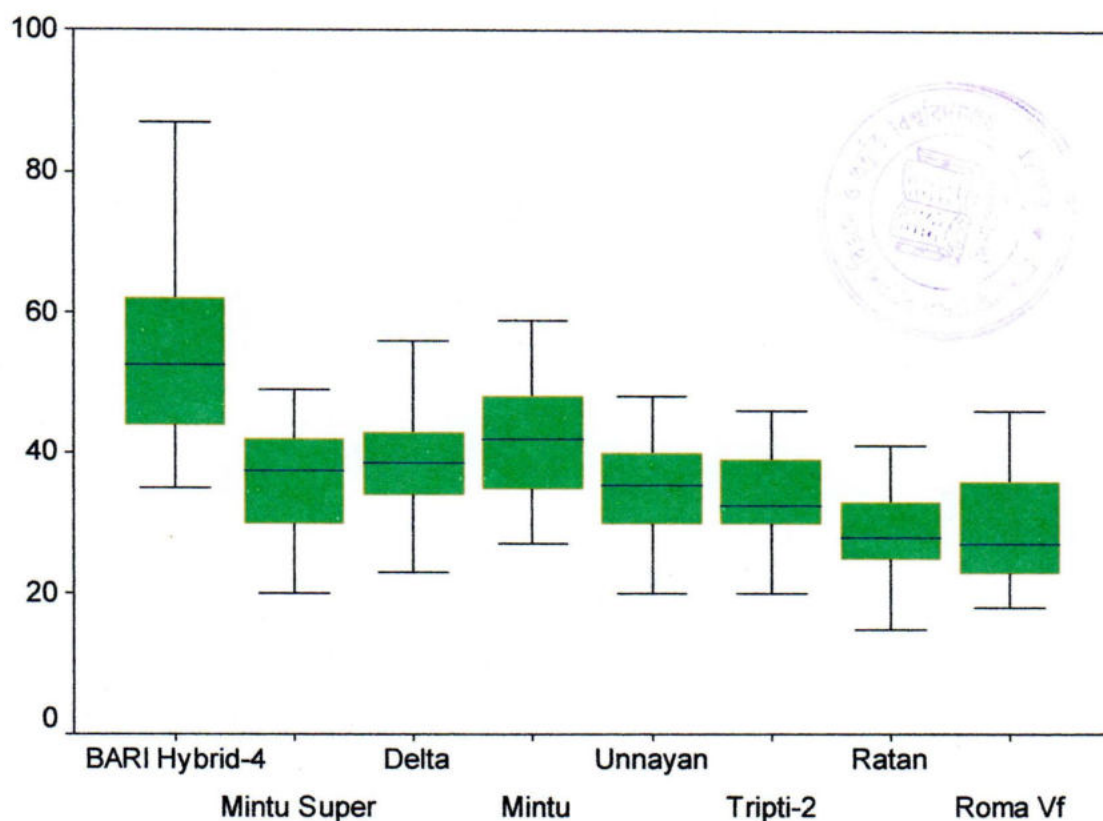


Fig. Box Plot for No. of Marketable fruits/ Plant of 8 tomato varieties

4.1.7 Individual Fruit Weight

The analysis of variance showed highly significant differences among the varieties (Table 1). The mean values showed a wide range of variation among the varieties for this character ranged from 40.62g to 90.94g. Padma and Reddy (2006), Zorzoli (2000) and Ghosh *et al.* (2010) reported the similar variation for fruit weight. But Pradeepkuma *et al.* (2011) reported a wide range of fruit weight ranged from 1.40-115.00g. The hybrid Mintoo Super (90.94g) gave the highest mean value of individual fruit weight which was significantly superior to all other hybrids and local Popular varieties. The Mintoo super was statistically identical with BARI Hybrid -4 and Delta, Mintoo and the Popular check variety Roma Vf. The lowest individual fruit (40.62) was observed in Tripti-2 which was statistically similar with Unnnayan and Roma Vf. Ahmed (1987) reported that a wide range of variation was observed for individual

fruit weight. But Brar *et al.* (1998) found average fruit weight ranged between 24.10g and 76.60g.

Phenotypic variance (514.919) is very high than genotypic variance (283.989) indicating the high environmental influence on this trait (Table 3). Sonone *et al.* (1986) reported highest values for genotypic and phenotypic variance for this trait. There were also significant differences among phenotypic (28.772) and genotypic (38.479) co-efficient of variation indicating moderate influence on environment for this character. Highly Phenotypic and genotypic variance were also observed by Sonone *et al.* (1986), Reddy and Reddy (1992).

The box plot showed that the uniform fruit weight and least variation were found in Unnayan, BARI hybrid-4, Mintoo and Tripti-2 which was less than the check varieties Ratan and Roma Vf. Delta and Mintoo super recorded the moderate variation for this trait but less than check varieties Ratan and Roma Vf. The check varieties recorded the maximum variation in their fruit weight which was higher than all other check varieties.

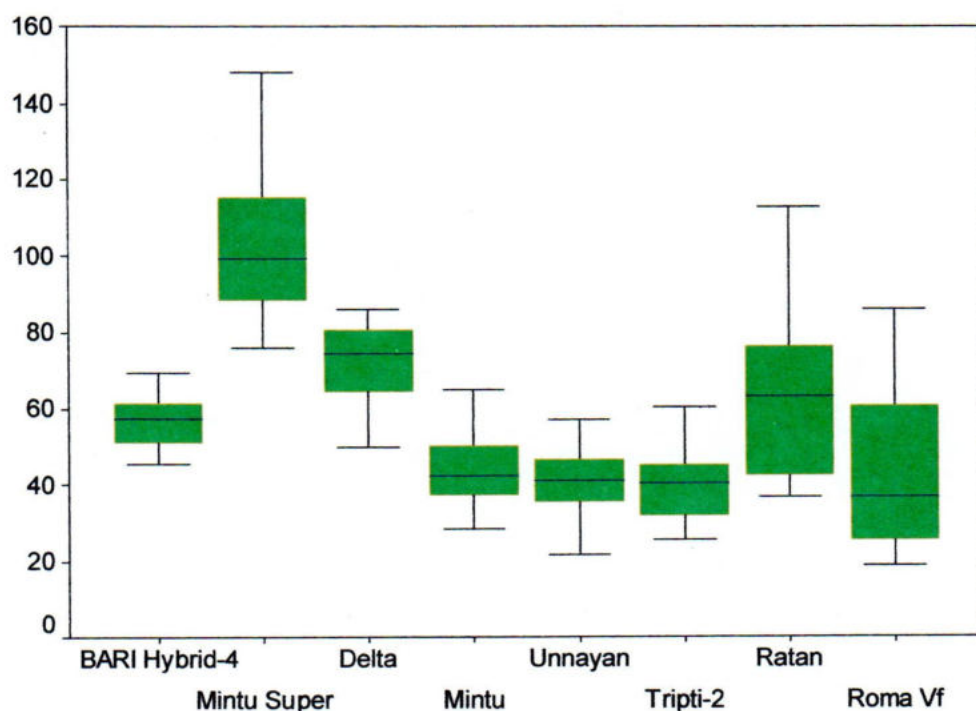


Fig. Box Plot for Individual Fruit Weight of 8 tomato varieties

4.1.8 Shelf Life

Shelf life is the basic quality which helps to extend marketing and consumption period of fruits. The extension of shelf life of fruits has been one of the prime concerns of the researchers (Salunkhe and Desai, 1984). The shelf life of tomato fruits was significantly influenced by maturity stage. A wide range of variation was found among the varieties for the shelf life and it ranges from 5.67 days to 14.33 days. The harvested fresh ripe fruits of Tripti-2 could be remain fresh *i.e.* shelf life is upto 14.33 days which was identical with the hybrid Delta (13.67 days) and the check variety Roma vf (13.00 days). Hybrids e.g. Mintoo (11.33), BARI hybrid-4(10.00) and Unnayan (9.33 days) and with the check variety Ratan was no significant differences among them. Mintoo super (8.33 days) could not be degenerated as in the hybrid Unnayan and BARI hybrid-4.

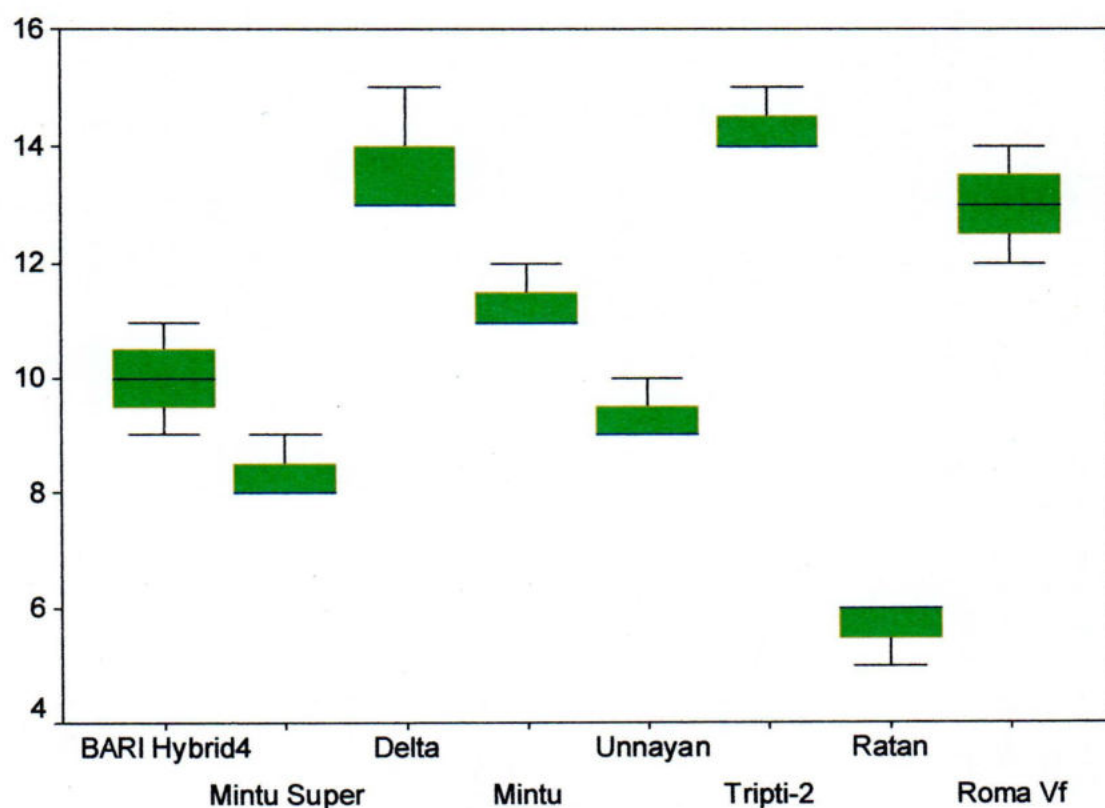


Fig. Box Plot for Shelf Life of 8 tomato varieties

The check variety Ratan could be as consumable after harvest in lowest *i.e.* 5.67 days which is different from all other hybrids and the Check varieties. Parvinder *et al.* (2002), TingTing *et al.* (2005), Rodriguez *et al.* (2005) and Prema *et al.* (2011) recorded the similar shelf life in their study.

Boxplot displayed the empirical distribution of the six tomato hybrids and the checks for the character shelf life of harvested fruits. The boxplot showed that the hybrid Mintoo super, Mintoo, Unnayan, Tripti-2 was minimum variation for shelf life whose are similar with the popular varieties Ratan and Roma Vf. Mintoo super and Delta was found moderate variation for this trait than the check varieties Ratan and Roma Vf.

4.1.9 1000 Seeds Weight

The 1000 seed weight is one of the most important characters for choosing the cultivation of tomato hybrids. There were a less variation among the hybrids and the check varieties Ratan and Proben seed and its ranges from 2.97 g to 4.15 g. The hybrid Delta gave the highest 1000 seed weight (4.15 g) and was the highly significant differences among the hybrids and the check varieties. Hybrids Mintoo super, Mintoo and popular check variety Ratan and Roma Vf had no significant differences among these varieties for the character 1000 seeds weight. The lowest weighted seeds were produced by hybrid BARI hybrid-4(2.97 g) which was identical with hybrids Unnayan (3.16 g) and Tripti-2(3.18 g). Rodrigues *et al.* (2001) reported the similar variations in 1000 seed weight in their experiment.

Boxplot showed that the hybrids BARI hybrid-4(2.97 g), Mintoo and Tripti-2 (3.18g) had produced lighter weighted seeds as well as least variation was recorded in their 1000 seed weight which was similar to Ratan and less variation than Roma Vf. Unnayan and Mintoo super recorded a moderate variation for this trait which was higher than check varieties Ratan and Roma Vf.

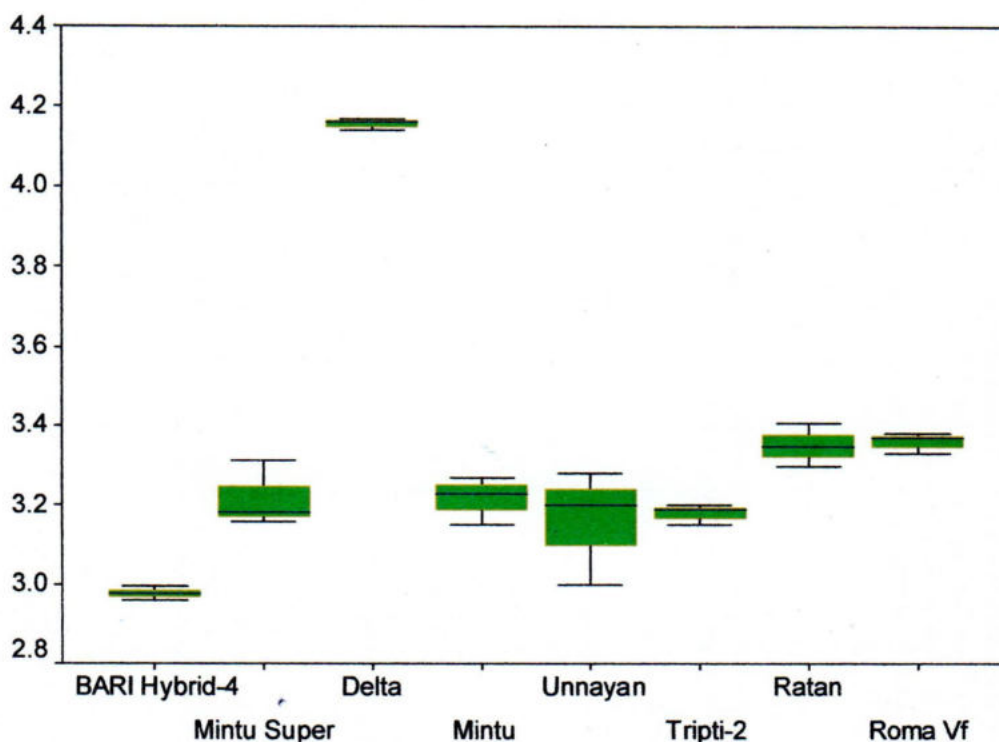


Fig. Box Plot for 1000 Seed Weight of 8 tomato varieties

4.1.10 Yield per Plant

Wide range of variation was found among the varieties for yield per plant and its ranges from 1.287 to 3.047 kg. The highest (3.047kg) yield per plant was produced by the hybrid Mintoo Super and Delta (2.536). There are no significant differences among the hybrid varieties Delta and BARI hybrid-4(2.308) and the check variety Ratan(2.007). Again hybrids e.g. BARI Hybrid-4, Mintoo and Unnayan with the check varieties Ratan and Roma Vf was identical. The lowest yield per plant was recorded in Tripti-2 which was similar with Mintoo, Unnayan and with checks Ratan and Roma Vf. Aditya (1995) reported that yield per plant ranged between 1.05kg and 2.51kg While Matin (2001) obtained the maximum yield per plant of 2.80 kg and the minimum yield per plant of 1.30kg. Nsowah (1970) and Norman (1974) found significant differences among the cultivars for yield. Reddy *et al.* (1992) found considerable variation for this trait. Pujari *et al.* (1995) and Ghosh *et al.* (1995), Srinivas (2001) and Joshi and Kohli (2003) observed highest variation occurred for yield/plant, which is supported by the present findings. Pradeepkuma *et al.* (2011) observed that yield per plant exhibited a range of 80.00-2370.00g.

The Phenotypic variance(0.368) is slightly higher than the genotypic variance(0.304) indicating the negligible environmental influence on this trait (Table 3) and the genotypic co-efficient of variation (19.838%) to that of the Phenotypic co-efficient of variation (23.161%) was considerable variation which indicate the environmental influence on yield per plant. Matin (2001) also reported that phenotypic variance was little higher than genotypic variance. Aditya (1995) reported that phenotypic co-efficient of variation were than genotypic co-efficient of variation for yield per plant.

From the boxplot it was easily displayed that the empirical distribution of six hybrids and the two check varieties for the character yield per plant. The boxplot showed that the hybrid BARI hybrid-4 and Unnayan displayed the minimum variation for this trait than the other hybrids e.g.Mintoo super, Delta, Mintoo and Tripti-2 and the check varieties Ratan and Roma Vf. Tripti-2 and Miintu showed slightly moderate variation in yield per which less than popular check varieties Ratan and Roma Vf. Mintoo super and Delta produced moderate variation which was identical with popular check varieties Ratan and Roma Vf.

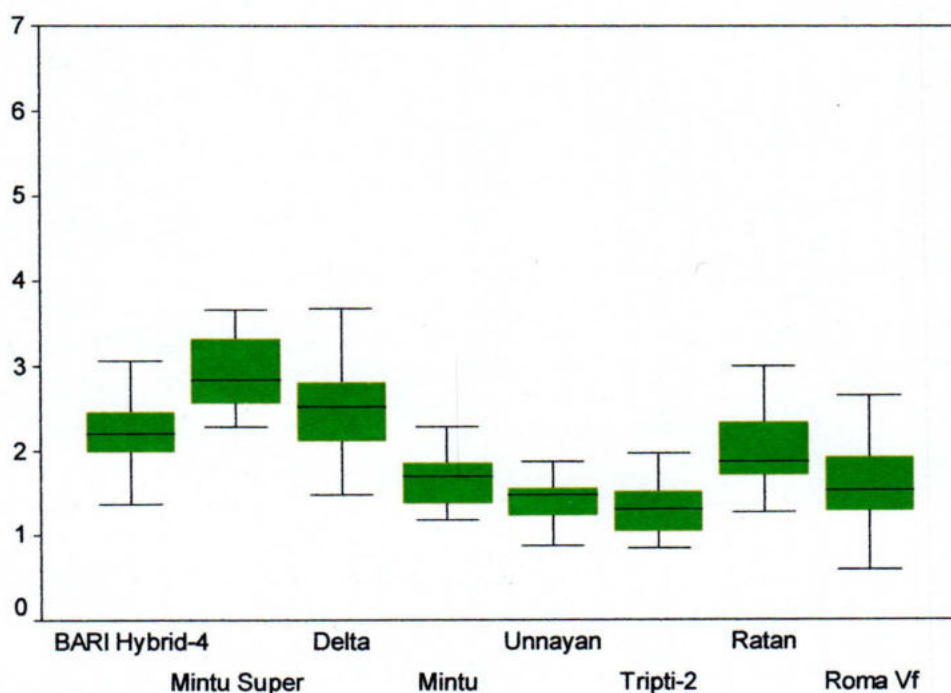


Fig. Yield per Plant (Kg) in 8 tomato varieties

4.2 Comparison of Hybrids with Check Varieties

The comparison between the promising two local, popular and most cultivated tomato varieties with different hybrids studied in this experiment are discussed in this section.

4.2.1. BARI Hybrid-4 and Check Varieties

BARI hybrid-4 was recorded the relatively shorter days(44.67 days) required for 50% flowering than the check varieties Ratan and Roma Vf required 45.67 and 47.67 days respectively after transplanting of the tomato seedling. The hybrid also produced thicker fruit diameter (51.92 mm) than the check variety Roma Vf (44.58mm) but smaller size diameter than Ratan (60.38). BARI hybrid-4 produced smaller fruit length (40.28mm) than two check varieties Ratan (52.68mm) and Roma Vf(53.91mm). It also produced heavier weighted fruits (60.08g) than check variety Roma Vf(43.33g) and lighter weighted than the check variety Ratan(67.40g). The hybrid also produced a longer plant height (78.33cm) than the other checks varieties Roma vf (76.33cm) and Ratan (73.23cm). The surrounding area of the hybrid *i.e.* canopy width (75.23cm) was significantly wider than Ratan (59.60cm) and Roma Vf (36.77cm). BARI hybrid-4(53.97) also produced significantly higher number marketable fruits than Roma Vf (30.70) and Ratan(28.67). It was recorded that the hybrid produced lighter weighted seeds (2.97 g) than the other two check varieties Ratan (3.35g) and Roma Vf(3.36g). The harvested fresh ripe fruit remain consumable *i.e.* shelf life an average 10 days which was relative longer than the check variety Ratan (5.67 days) and shorter than the check variety Roma Vf (13 days). Finally, the yield per plant (2.308Kg) as well as yield over the replication is higher than two popular checks Ratan and Roma Vf produced 2.007kg and 1.669 kg respectively.

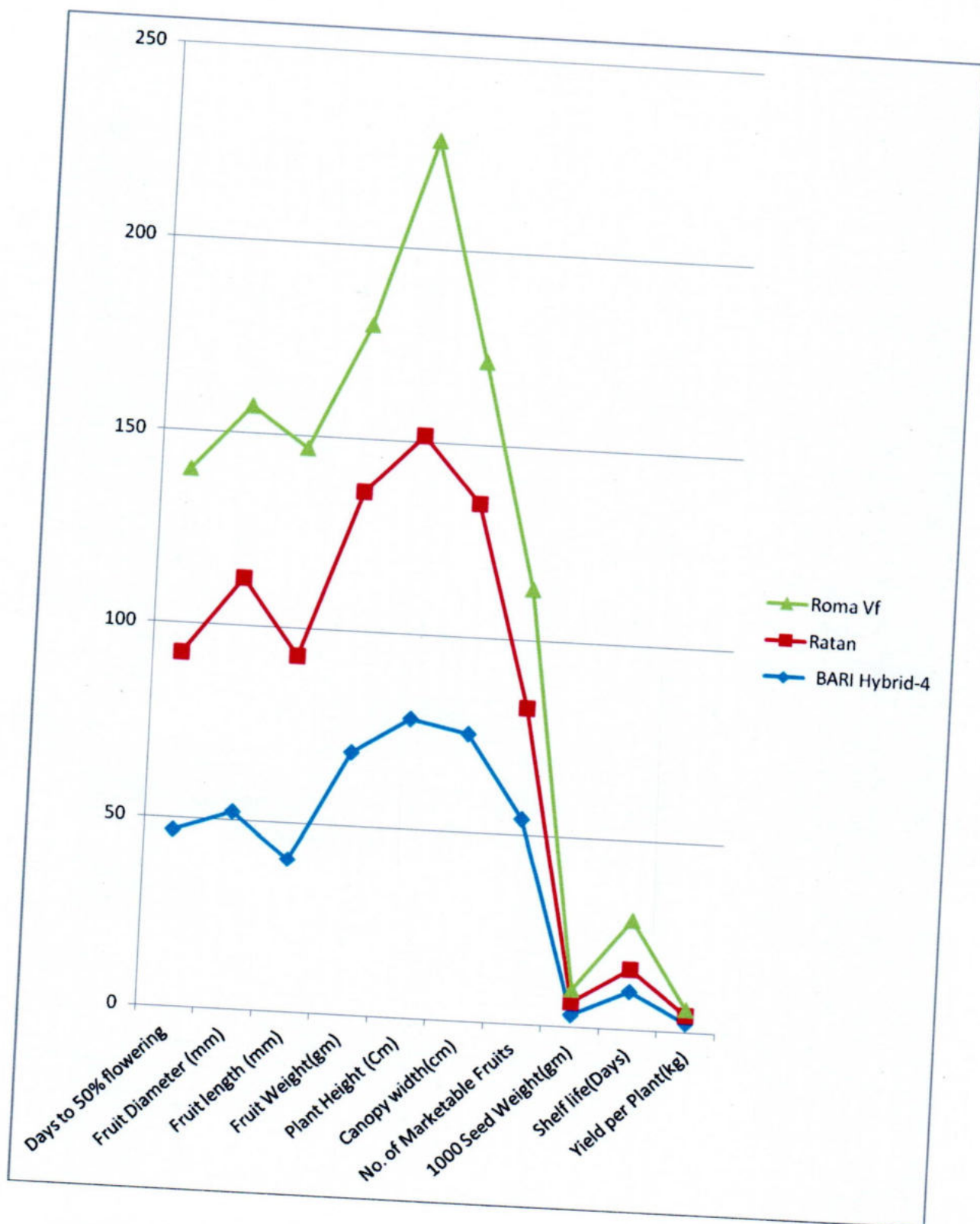


Figure 11: Comparative feature of BARI hybrid-4 with check varieties

4.2.2. Mintoo Super and Check varieties

There were highly significant variations between the check varieties and Mintoo super on ten important yield and yield contributing characters. Mintoo super (46.67days) required the longer days for their 50% flowering than the check variety Ratan(45.67) and shorter days than Roma Vf(47.67days). It produced fruits diameter (59.85mm) was slightly smaller than Ratan (60.38mm) and highly thicker than Roma Vf (44.58). Mintoo super produced pear shape and short fruit size *i.e.* fruit length (49.41mm) was smaller than the other check varieties Ratan and Roma Vf gave fruit diameter 52.68mm and 53.91mm respectively. It produced largest and heavier fruits (90.94 g) than the checks Ratan (67.40g) and Roma Vf (43.33 g). The hybrid also produced the longer plant height (83.07cm) than other checks Ratan and Roma Vf gave the plant height 73.23cm and 76.33cm respectively. The surrounding area of the hybrid also produced wider canopy width (69.73cm) than other check varieties Ratan(59.60cm) and Roma Vf (36.77cm). Mintoo super also higher amount of marketable fruits (37.77) per plant than other check varieties Ratan and Roma Vf produced an average 28.67 and 30.70 frutis respectively per plant. For hybrid production one of the main constrains is the cost of hybrid seed is high. The 1000 seed weight (3.218g) was recorded lighter than the other check varieties Ratan(3.35 g) and Roma Vf(3.36g). The harvested fresh fruits can be remain consumable an average 8.33 days which was longer than the check Ratan (5.67days) and shorter than another check variety Roma Vf (13.00 days). Finally, the yield per plant as well as yield over the replication was significantly higher in Mintoo super (3.047 kg) than the other check varieties Ratan and Roma Vf produced 2.007kg and 1.67kg yield per plant respectively.

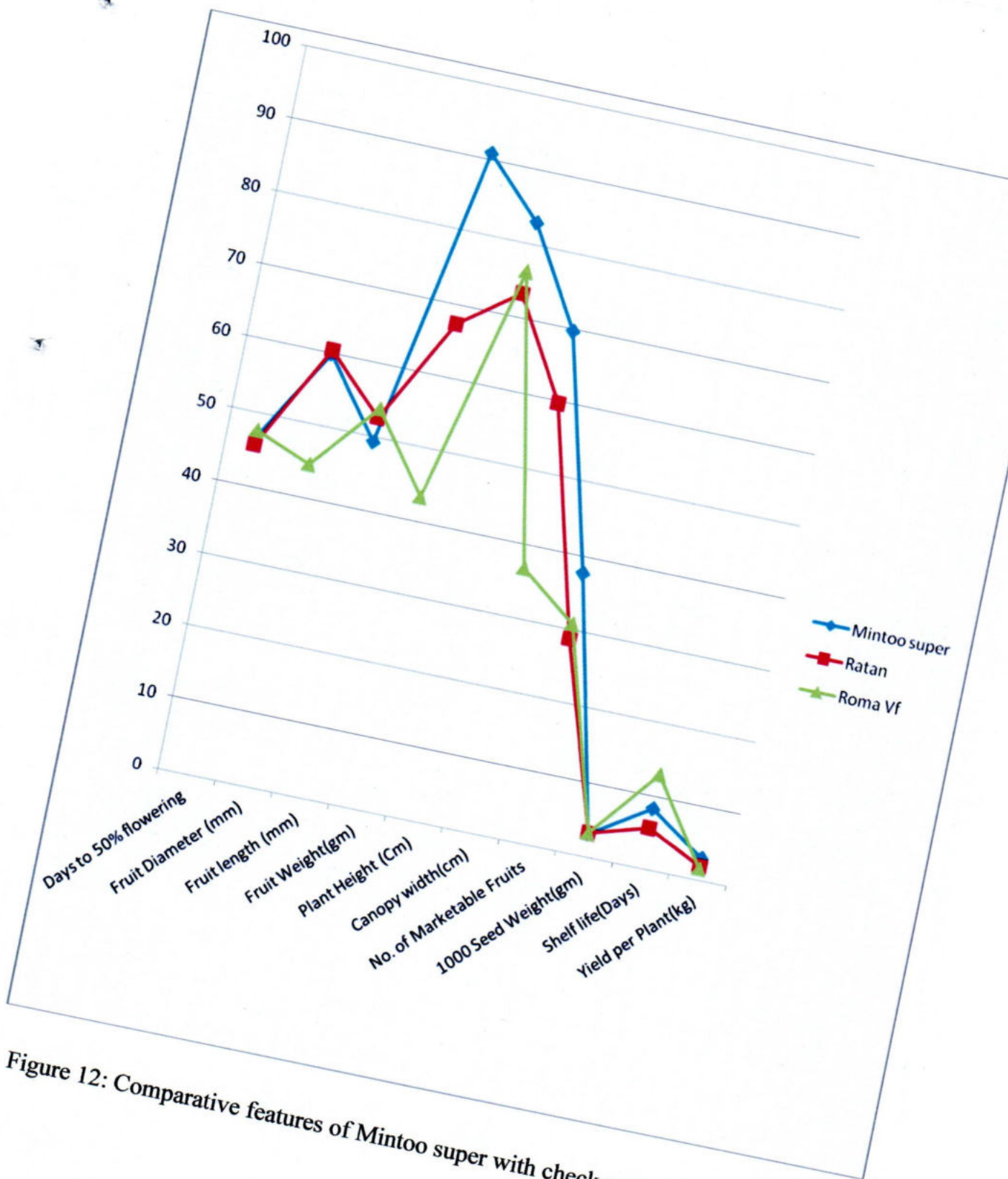


Figure 12: Comparative features of Mintoo super with check varieties

4.2.3. Delta and Check varieties

There were significant differences among the check varieties Ratan and Roma Vf with hybrid variety Delta. It gave 50% flowers (48.00days) later than other two check varieties Ratan and Roma Vf required 45.67 and 47.67 days for their 50% flowering. Delta produced fruit diameter (51.57mm) which was smaller than the check Ratan (60.38mm) but thicker than another check variety Roma Vf (44.58mm). It produced a round shape fruit which had smaller fruit length (48.73mm) than check varieties Ratan and Roma Vf produced 52.68mm and 53.91mm respectively. The hybrids also produced the heavier fruits (72.80g) than other check varieties Ratan (67.40g) and Roma Vf (43.33g). The hybrid Delta(81.13 cm) also produced highly significant different plant height which was longer from the other popular and promising check varieties Ratan and Roma Vf produced the plant height 73.23 cm and 76.33 cm respectively. The surrounding area *i.e* canopy width (83.03 cm) was wider than other check varieties Ratan (59.60 cm) and Roma Vf(36.77 cm). The production of marketable fruits (38.20) also higher amount than the other check varieties Ratan and Roma Vf gave 28.67 and 30.70 fruits respectively. The 1000 seeds weight (4.157 g) was heavier than other two checks Ratan(3.35 g) and Roma Vf(3.36 g). The fresh harvested fresh ripe fruits was remain consumable *i.e*. shelf life (13.67days) was longer than the other two check varieties Ratan (5.67) and Roma Vf(13.00). Finally ,the yield per plant (2.536 kg) as well as yield over the replication (25.36 kg) is significantly higher than check varieties Ratan and Roma Vf produced 2.007 kg and 1.669 kg respectively yield per plant.

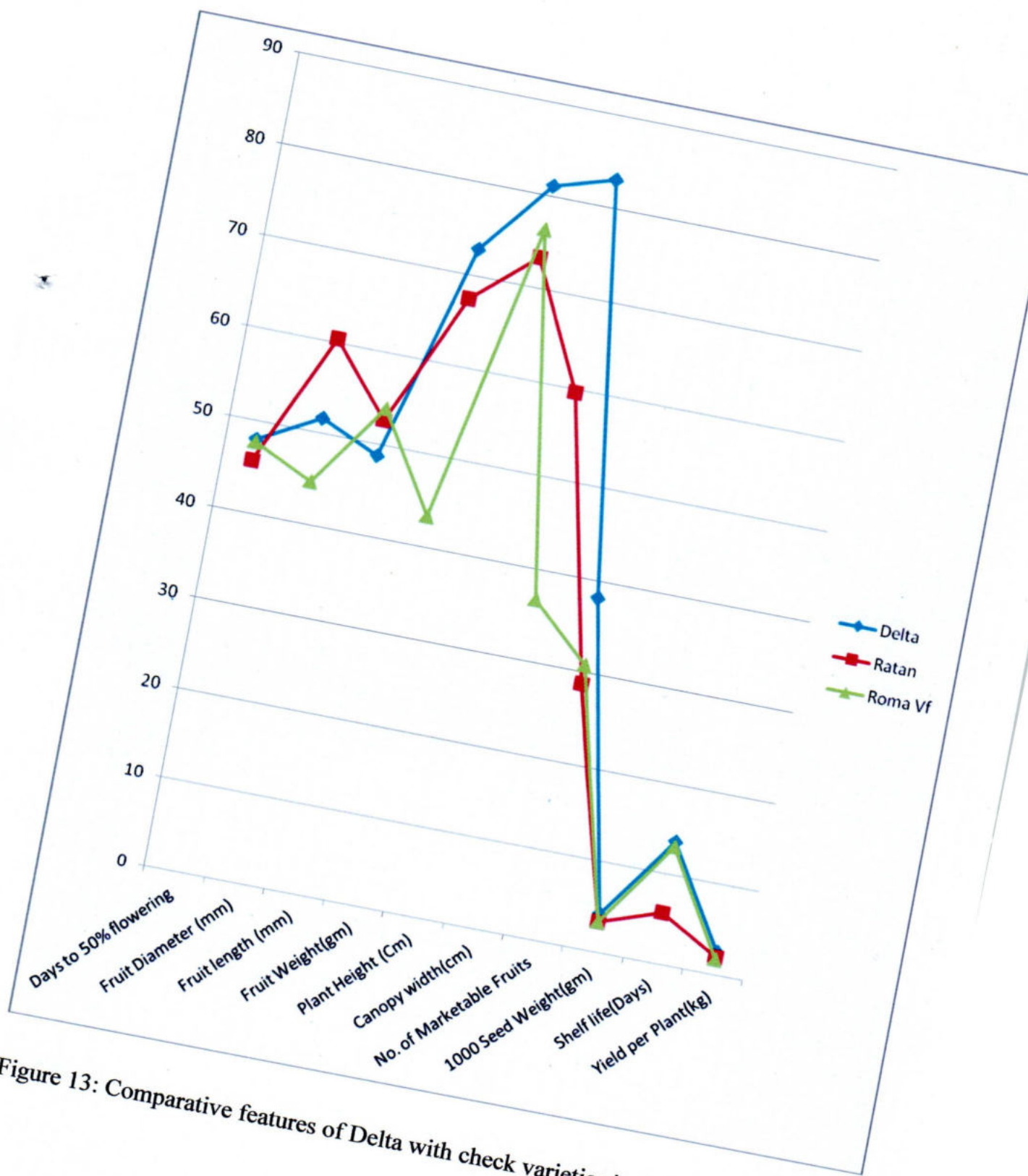


Figure 13: Comparative features of Delta with check varieties in different characters

4.2.4. Mintoo and Check Varieties

There were a less variation was observed in the hybrid Mintoo than other two check varieties Ratan and Roma Vf. Mintoo required 45.00 days for 50% flowering *i.e* flowering period was earlier than the check varieties Ratan and Roma Vf required 45.67 and 47.67 days respectively for their 50% flowering. Mintoo produced fruit diameter (47.30 mm) which was thicker than Roma Vf (44.58 mm) and smaller than Ratan(60.38 mm). The fruit of Mintoo was round shape *i.e.* its fruit length(44.11 mm) was smaller than two promising and popular check varieties Ratan and Roma Vf produced 52.68 mm and 53.91 mm respectively. The fruit weight is another important yield contributing character for tomato hybrids. The weight of individual fruit (43.58 g) was similar to the check variety Roma Vf (43.33 g) and lighter than the other check variety Ratan which produced an average fruit weight 67.40 g. Mintoo also produced the shorter size plant *i.e.* its plant height(62.43cm) was shorter than the other check varieties Ratan (73.23cm) and Roma Vf (76.33 cm). Its surrounding area *i.e.* canopy width (39.87 cm) was wider than Roma Vf(36.77 cm) and smaller than Ratan (59.60 cm). Mintoo also produced the high amount of marketable fruits (41.17) than other two popular checks Ratan(28.67) and Roma Vf(30.70). The weight of 1000 seeds (3.217 g) is lighter than the other two popular varieties Ratan (3.35 g) as well as Roma Vf (3.36 g). The harvested fresh ripe fruit was remain consumable an average 11.33 days which was longer than Ratan (5.67 days) and shorter than the check Proben seed (13.00 days). Finally, the yield per plant (1.685 kg) as well as yield over the replication (16.85 kg) was identical with Roma Vf (1.669 kg) but lower than the promising variety Ratan(2.007kg)

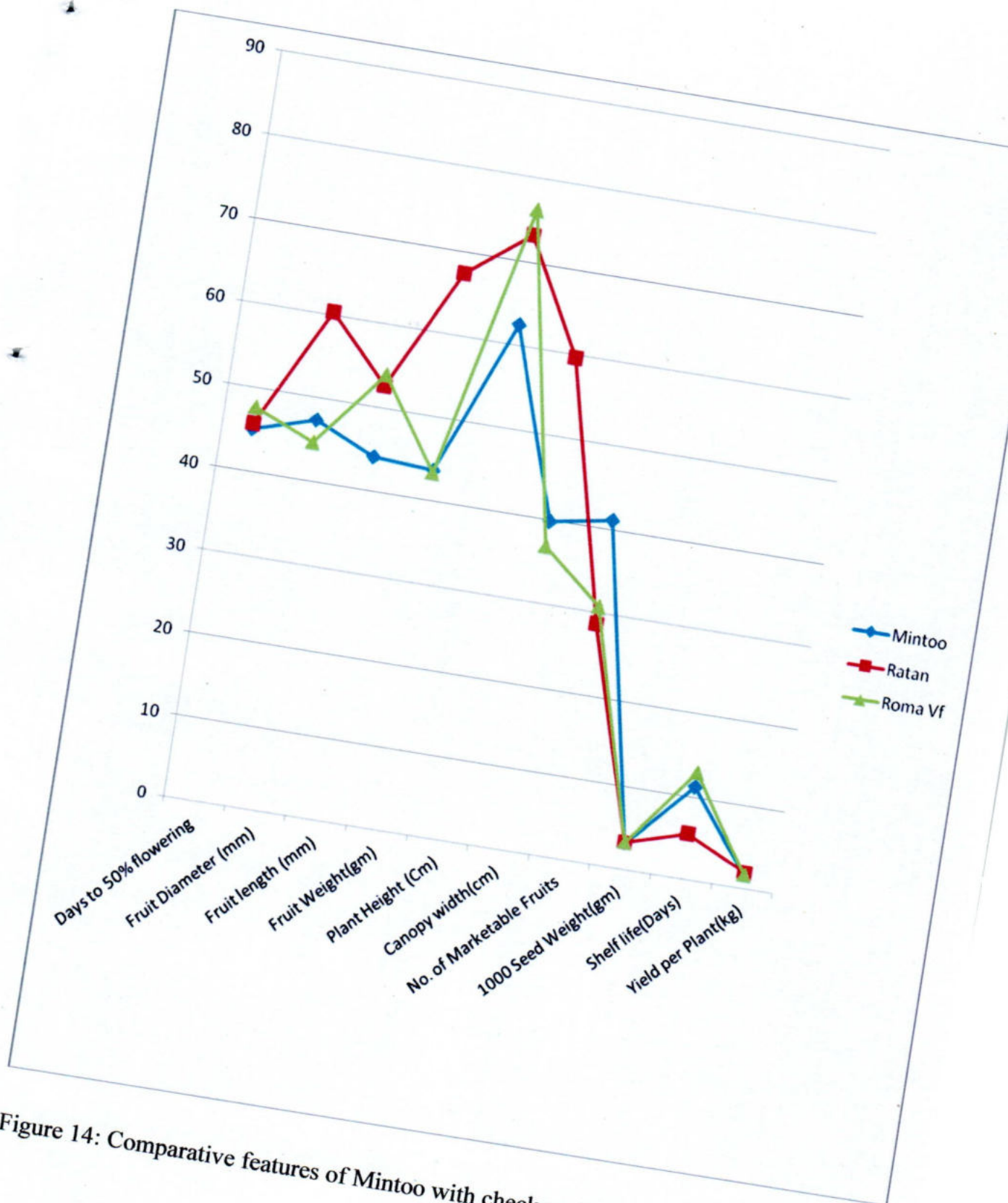


Figure 14: Comparative features of Mintoo with check varieties

4.2.5. Unnayan and Check Varieties

Unnayan gave the 50% flowers (40.67 days) earlier than the popular check varieties Ratan and Roma Vf whose required 45.67 and 47.67 days respectively for their 50% flowering. It also gave smaller fruit diameter (40.02 mm) than the popular varieties Ratan(60.38 mm) and Roma Vf(44.58). Unnayan produced spherical shape fruits *i.e.* fruit length was larger than the two popular varieties Ratan and Roma Vf produced fruit length 52.68 mm and 53.91 mm respectively. Unnayan produced smaller as well as lighter fruits (40.90 g) compared to the popular check varieties Ratan and Roma Vf whose gave the individual fruit weight 67.40 g and 43.33 g respectively. The height of the plant (58.17 cm) also shorter than other two checks Ratan (73.23 cm) and Roma Vf (76.33). The surroundings area of the plant Unnayan was wider than Roma Vf (36.77 cm) and shorter coverage than Ratan (59.60 cm). The production of marketable fruits (34.60) is higher than the checks Ratan and Proben seed whose produced 28.67 and 30.70 fruits respectively per plant. The weight of 1000 seeds (3.16 g) were lighter than the two popular varieties Ratan(3.35 g) and Roma Vf(3.36 g). The harvested fresh ripe fruit was remain consumable *i.e.* shelf life was 9.33 days which longer than Ratan (5.67 days) and shorter than Roma Vf (13.00 days). Finally, the yield per plant of Unnayan (1.708 g) is slightly higher than the check Roma Vf (1.669 kg) and lower than the check Ratan(2.007 kg).



Figure 15 : Comparative features of Unnayan with check varieties

4.2.6. Tripti-2 and Check Varieties

Tripti-2 required 43.33 days for their 50% flowering *i.e.* flowering is earlier than the other two popular check varieties Ratan and Roma Vf whose required 45.67 and 47.67 days for their 50% flowering. The thickness of the fruit (43.62 mm) was smaller than the other two check varieties Ratan (60.38 mm) and Roma vf (44.58 mm). The length of the fruit (45.53 mm) was also shorter than other checks Ratan(52.68 mm) and Roma Vf(53.91 mm). The weight of individual fruit (40.62 g) was also lighter compared to other check varieties Ratan and Roma Vf produced 67.40 g and 43.33 g respectively. Tripti-2 produced a shorter size plant(56.43 cm) compared to popular varieties Ratan and Roma Vf produced a plant height 73.23 cm and 76.33 cm respectively. It also produced a shorter canopy area (39.73 cm) than the check variety Ratan (59.60 cm) but wider than the check variety Roma Vf (36.77 cm) . The production of marketable fruits (33.33) was higher than the popular check variety Ratan and Roma Vf whose gave 28.67 and 30.70 fruits respectively. The 1000 seed weight (3.18 g) was lighter than other two check varieties Ratan (3.35 g) and Roma Vf (3.36 g). The harvested fresh ripe fruit was remain consumable *i.e.*, shelf life was an average 14.33 days which significantly higher than the other two popular varieties Ratan and Roma Vf whose shelf life was 5.67 and 13.00 days respectively. Finally, the yield per plant (1.287 kg) as well as yield over the replication (12.87 kg) was lower than the other two popular check varieties Ratan and Roma vf produced the yield per plant was recorded 2.007kg and 1.669kg respectively.

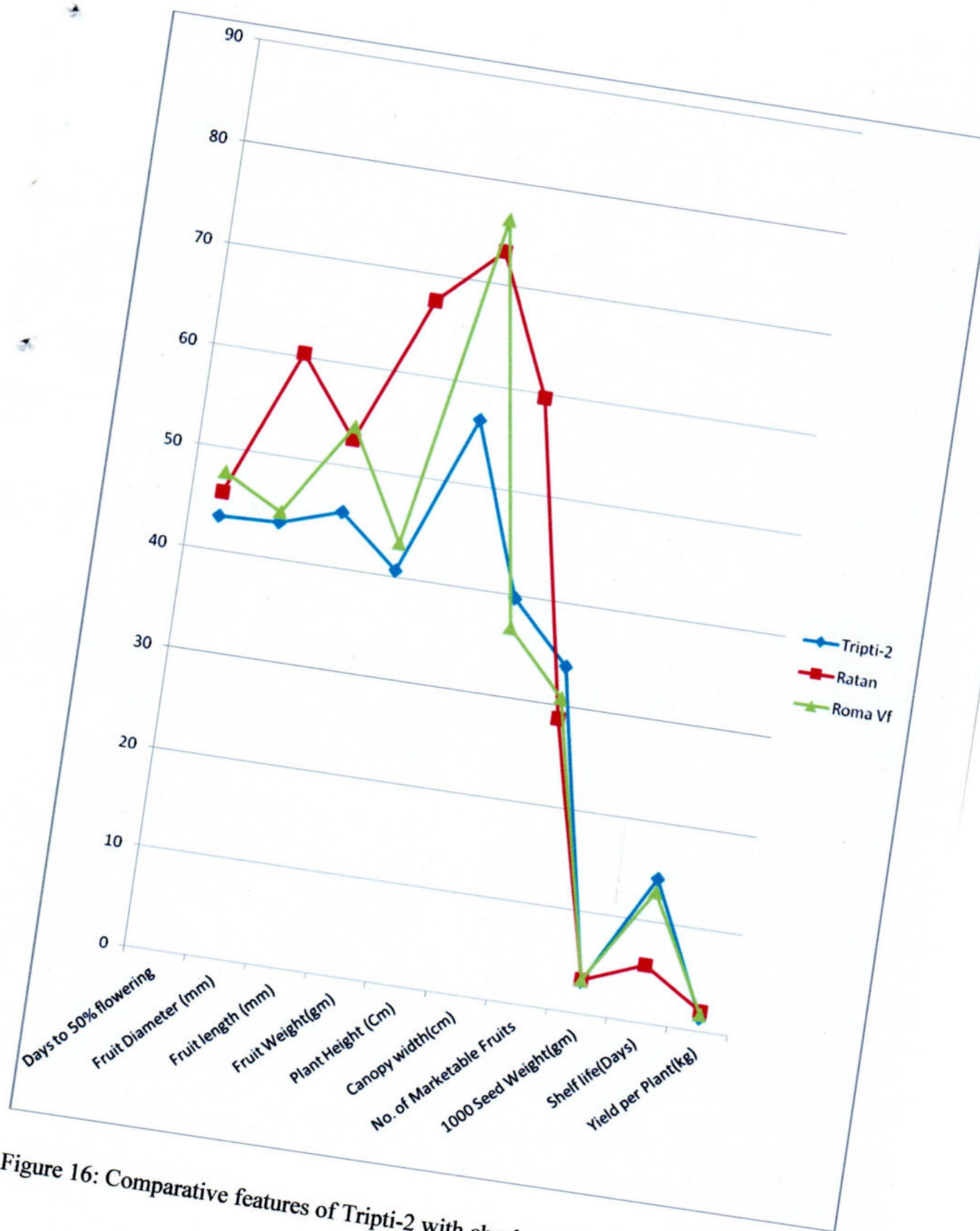
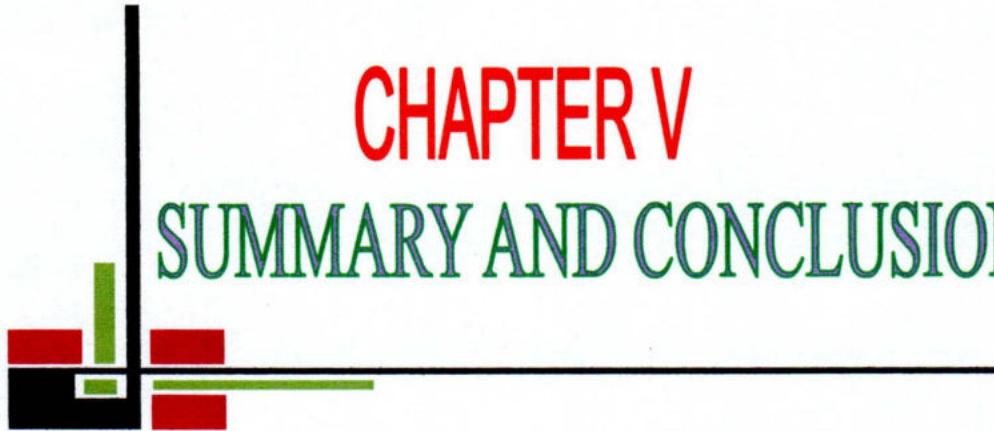


Figure 16: Comparative features of Tripti-2 with check varieties



CHAPTER V

SUMMARY AND CONCLUSIONS



CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was carried out at the experimental field of Genetics and Plant Breeding, Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period of November, 2011 to April, 2012. It was involved with six tomato hybrids and two check varieties. The experiment was conducted in Randomized Complete Block Design with three replications. The experimental data were collected on 10 different important characters viz. days to 50% flowering, fruit diameter, fruit length, individual fruit weight, plant height, canopy width, number of marketable fruits, shelf life, 1000 seed weight and yield per plant etc. Statistical analysis was done using the mean values of the varieties for each character. The summary of the study has been arranged on the basis of characters studied.

The significant mean squares for days to 50% flowering indicated the presence of variability among the hybrids. The days to 50% maturity ranged from 40.67-48.00. Among the hybrids Unnayan (40.67) took minimum days for 50% flowering than all other hybrids and check varieties. Delta (48.00) took maximum days for their 50% flowering. Least variation was found in BARI hybrid-4 and highest variation was found in Delta.

It was observed that there were significant variations among the hybrids for all the characters studied. A wide range of variability (56.43-83.07cm) among the hybrids and the check varieties was found in case of plant height. Mintoo super was the tallest hybrid among the hybrids and check varieties followed by Delta and BARI hybrid-4. The hybrid Tripti-2 was the shortest hybrid in plant height. Least variation was found in Mintoo and highest variation was found in check variety Roma vf. The estimates of genotypic and phenotypic variance were 102.75 and 131.20 respectively.

The thicker fruit diameter was found in check variety Ratan (60.38 mm) followed by hybrid Mintoo super (59.85mm). The shortest fruit diameter was 40.02mm in the hybrid Unnayan. Least variation was found in Delta followed by Tripti-2 than other

hybrids and check varieties. The lower genotypic (53.58) and higher phenotypic (58.74) variance indicate the moderate environmental effects on this trait.

The hybrid Unnayan (55.97 mm) produced the longest fruit followed by the check variety Roma vf. The shortest fruit had in BARI hybrid-4(40.28mm) followed by Mintoo super (44.11mm). The phenotypic and genotypic co-efficient of variation was 10.73 and 11.21 respectively indicate low influence on environment. Least variation was observed in Delta and most variation was recorded in check variety Roma vf.

Individual fruit weights showed the significant differences among the hybrids. It ranges from 40.62 to 90.94 g. Mintoo super (90.94 g) produced the heavier weighted fruits than all other hybrids and check varieties. The lightest fruit was produced by the hybrid Tripti-2(40.62 g). The highest variation was found in the check varieties Ratan and Roma vf whereas least variation was observed in BARI hybrid-4. The genotypic variance (283.98) and phenotypic variance (514.91) indicated that environmental effects were higher on this trait.

Highly significant variation was found in canopy width among the hybrids and the check varieties. The hybrid Delta (83.03 cm) produced wider canopy than other hybrids and check varieties followed by BARI hybrid-4 (75.23 cm). The shortest canopy area was produced by the check variety Roma vf (36.77 cm). Least variation was observed in Tripti-2 whereas maximum variation was found in the hybrid Delta for canopy width. The genotypic variance (329.41) was lower than phenotypic variance (356.271) indicates the moderate environmental effects on this trait.

The highest number marketable of fruits per plant was obtained from the genotype BARI hybrid-4 (53.97). The lowest number of marketable of was produced in check variety Ratan (28.67). Least variation was observed in Delta, while the hybrid BARI hybrid -4 exhibited the maximum variation for number of marketable fruits per plant. The genotypic and phenotypic co-efficient of variation indicates the little environmental effects on this trait.

The hybrid Tripti-2 (14.33) could be remains fresh *i.e.* shelf life maximum days than all other hybrids and check varieties followed by the hybrid Delta (13.67) and check variety Roma vf (14.00). The check variety Ratan (5.67) could be fresh *i.e.* shelf life was obtained the minimum days. Maximum variation was exhibited in BARI hybrid-4 whereas least variation was found in Roma vf. The genotypic (27.24) and phenotypic (24.19) co-efficient of variation indicates slight environmental effects on this trait.

Delta (4.16g) produced the highest 1000 seed weight. The lowest weighted seed was exhibited in the hybrid BARI hybrid-4 (2.97g). Least variation was observed in Tripti-2 while maximum variation found in Mintoo super. The genotypic and phenotypic variance indicates the no environmental effects on environment.

Mintoo super produced the highest fruits yield (3.047Kg) per plant followed by Delta (2.52 kg) and BARI hybrid-4 (2.30 Kg). The lowest yield of fruits was obtained in Tripti-2(1.28kg). Least variation was exhibited in Unnayan while maximum variation was recorded in Delta. The phenotypic (29.87) and genotypic co-efficient of variation indicates the little environmental effects on this trait.

From the breeder and farmers point of view the ultimate goal is yield as well as shelf life than any other character. Most of the farmers usually prefer high yielder and better shelf life in tomato than low yielding and shelf life varieties in the northern part of Bangladesh.

Mintoo super was the highest yielding hybrid possessed highest individual fruit weight and plant height and second highest fruit diameter. Mintoo super hybrid had moderate days required for 50% flowering, canopy width and number of marketable fruits per plant with medium shelf life but had the lower fruit length.

The second highest yielding hybrid Delta possessed second highest fruit weight and plant height. It also produced moderate shelf life but longest days required for 50% flowering. It also possessed the highest canopy width and 1000 seed weight, which contributed mainly to yield.

The third highest yielding hybrid was BARI hybrid-4, which had highest number of marketable fruits per plant and better fruit weight, which contributed mainly to yield, compared to the remaining other hybrids and the check varieties. It also produced Moderate plant height, fruit diameter, canopy width and lowest 1000 seed weight.

Based on this study Mintoo super is the highest yielding hybrid in and best hybrid for the Northern part of Bangladesh. An important trait defining fresh tomato marketability is fruit shelf life the Delta is better for both yield and shelf life. So, it may be concluded that the tomato single cross hybrids Mintoo super, Delta and BARI hybrid-4 are the promising hybrids than other hybrids and check variety Ratan and Roma vf in the Northern part of Bangladesh. Yield of Mintoo super, Delta, BARI hybrid-4 is higher than the check varieties Ratan and Roma vf but only the hybrid Delta has higher shelf life with less variable fruit characters than two check varieties.



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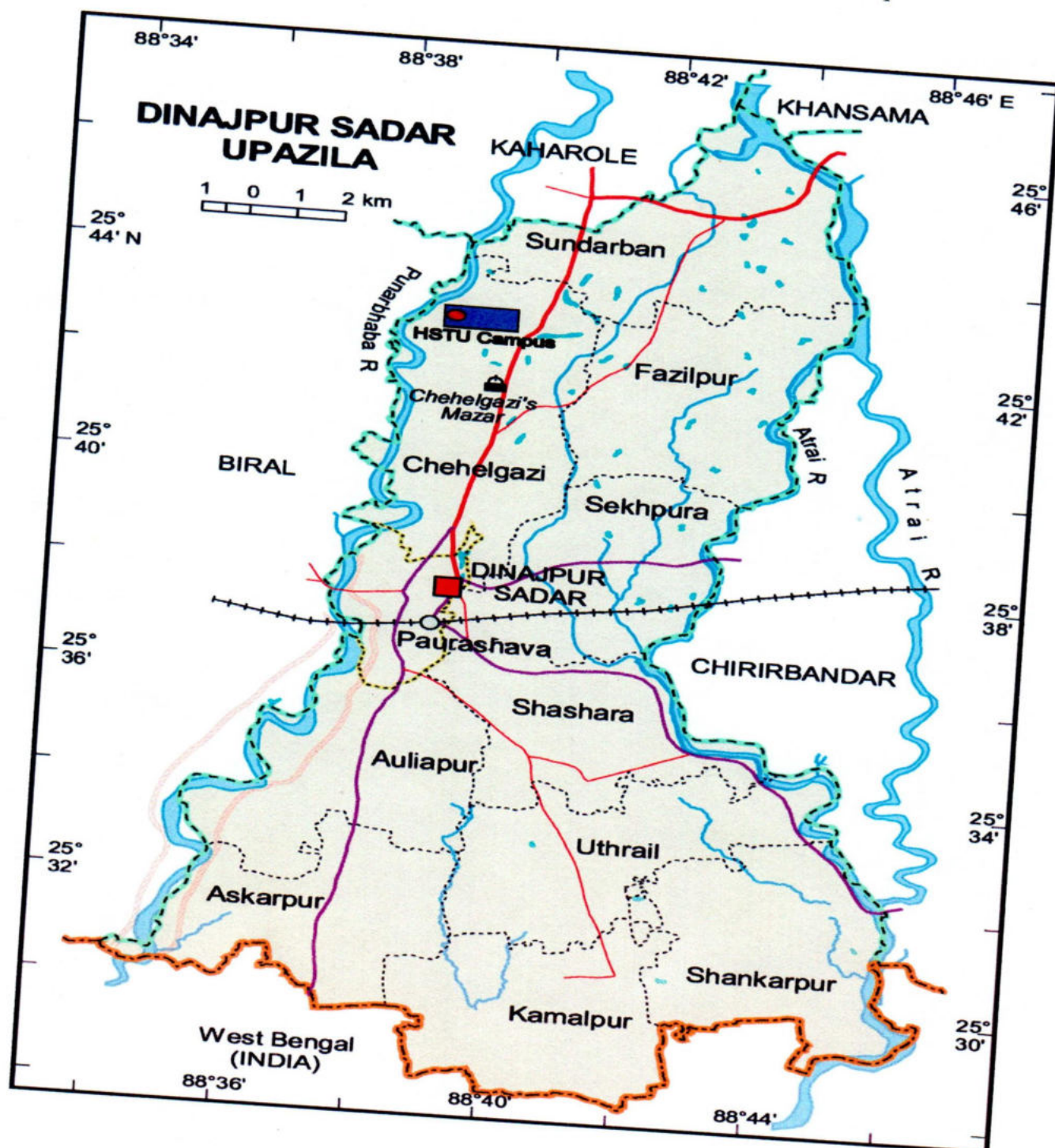
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APPENDICES

APPENDICES

Appendix I. Map of Dinajpur Sadar Upazila showing the experimental plot



Appendix-II: Physical and chemical properties of soil in experimental site

Soil characteristics	Physical and chemical properties	
Soil class	Ranisonkail high land	
Textural class	Sandy loam	
Sand (%)	65	
Silt (%)	30	
Clay (%)	5	
CEC(meq/100g)	8.07	
Collecting point	Point-30	Point-31
PH	5.4	4.8
Organic matter (%)	1.55	0.95
Total nitrogen (%)	0.08	0.05
Phosphorus ($\mu\text{g/g}$)	15	12
Potassium (meq/100g)	0.29	0.25
Zinc ($\mu\text{g/g}$)	1.78	0.9
Boron ($\mu\text{g/g}$)	0.44	0.38
Calcium (meq/100)	1.9	0.66
Magnesium (meq/100)	1.57	0.48
Copper ($\mu\text{g/g}$)	0.96	0.77
Iron ($\mu\text{g/g}$)	100.3	41.4
Manganese ($\mu\text{g/g}$)	112.7	58.7

Source: Land and soil utilization directory, Soil Resources Development Institute, Dinajpur (2010).

Appendix-III: Weather data of the experimental site during the period from
November 2011 to April 2012

Months	Air Temperature (° C)			*Rainfall (mm) (Minimum)	*Relative Humidity (%)
	Maximum	Minimum	Average		
November	29.6	15.9	22.75	0.0	89
December	21.9	10.9	16.4	0.0	90
January	21.8	9.6	15.7	4.0	83
February	29.2	18.7	23.95	8.0	86
March	29.2	18.7	23.95	3.0	86
April	29.2	18.7	23.95	33.0	85

*= Monthly Average

Source: Meteorological station, Wheat Research Center, Noshipur, Dinajpur.