PHENOLOGICAL CHANGES, YIELD AND QUALITY OF TOMATO *(Lycopersicon esculentum)* AS INFLUENCED BY DIFFERENT DOSES OF FERTILIZERS AND COWDUNG

A THESIS

By

SABINA YESMIN
Registration No.: 04-01364
Session: January-June, 2008

MASTER OF SCIENCE (MS)
IN
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This is to certify that the thesis entitled "**Phenological Changes, Yield and Quality of Tomato *(Lycopersicon esculentum)* as Influenced by Different Doses of Fertilizers and Cowdung**" submitted to the Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of **Master of Science (MS) in Agricultural Botany**, embodies the result of a piece of *bona fide* research work carried out by Sabina Yesmin, Registration No.: **04-01364**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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DEDICATION

I dedicate my thesis to my parents
whose efforts and ever
willing support have
made this dream
come true

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Sabina Yesmin

Sabina Yesmin

Place: Dhaka, Bangladesh

Dated: 27-11-11

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ABSTRACT

An experiment was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2008 to April 2009 to study the phenology, yield and quality of tomato *(Lycopersicon esculentum)* with different doses of fertilizers and cowdung. The two factorial experiment was laid out in a randomized complete block design (RCBD) with three replications. The experiment consisted of two factors, *viz.* factor A: Four levels of chemical fertilizer; F_0: control; F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha; F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha and F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha and factor B: Three levels of cowdung as C_0: Control; C_1: 5 ton cowdung/ha and C_2: 10 ton cowdung/ha with the following treatment combinations of F_0C_0, F_0C_1, F_0C_2, F_1C_0, F_1C_1, F_1C_2, F_2C_0, F_2C_1, F_2C_2, F_3C_0, F_3C_1 and F_3C_2. The urea, TSP, MP and gypsum were used as a source of N, P_2O_5, K_2O and S, respectively. The seedlings of tomato var. BARI Tomato-6 (chaiti) were raised at the nursery of the university farm. The plant height, number of leaves per plant and number of branches per plant were increased at different days after transplanting almost in the all treatments. The highest plant height (127.04 cm) and the lowest plant height (101.24 cm) were recorded with F_1C_2 and F_0C_2 treatment, respectively. The maximum number of leaves and branches were observed in F_2C_1. The highest number of flower cluster per plant, number of flowers per plant, number of flowers per cluster, number of fruits per plant, fruit length, fruit diameter and yield per hectare (67.93 t/ha) were observed from F_2C_1 treatment. In addition, F_2C_1 treatment produced tomato fruit earlier (76.30 days) than other treatments with highest shelf life (10.67 days). Separately, the highest content of total soluble solid of tomato was recorded in F_2C_2 treatment. No significant differences were observed between F_1C_2 and F_2C_1 treatment in respect of phenology, yield and quality of tomato. The treatment combinations of F_1C_2 might be recommended for tomato production rather than F_2C_1, due to sources of plant nutrients through cowdung is better than inorganic sources to keep safe environment.

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LIST OF ACRONYMS

ABBREVIATIONS	ELABORATIONS
%	Percent
^{0}C	Degree Centigrade
AEZ	Agro-Ecological Zone
Anon.	Anonymous
ANOVA	Analysis of Variance
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
cc	Cubic centimeter
cm	Centimeter
Conc.	Concentration
cv.	Cultivar(s)
DAS	Days after sowing
DAT	Days after transplanting
DMRT	Duncan's Multiple Range Test
e.g.	example
et al.	and others
etc.	etcetera
FAO	Food and Agriculture Organization
gm	Gram
ha	Hectare
IRRI	International Rice Research Institute
J.	Journal

LIST OF ACRONYMS (cont'd)

ABBREVIATIONS	ELABORATIONS
kg	Kilogram
Kg/ha	Kilogram per hectare
LSD	Least Significant Difference
m	Meter
m^2	Square meter
me	Miliequvalent
ml	Milliliter
mm	Millimeter
NGOs	Non Government Organizations
nm	Nano meter
NS	Non Significant
OM	Organic matter
pH	Hydrogen ion concentration
ppm	parts per million
q	Quintal
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources Development Institute
t/ha	Ton per hectare
TSP	Triple Superphosphate
UNDP	United Nations Development Program
USDA	United States Department of Agriculture
viz.	Videlicet/Namely

Chapter I

Introduction

CHAPTER 1

INTRODUCTION

Tomato (*Lycopersicon esculentum*) belongs to the family Solanaceae is one of the most important, nutritious and popular vegetable crops. The centre of origin of the genus *Lycopersicon* is the Andean zone particularly Peru-Ecuador-Bolivian areas (Salunkhe *et al.*, 1987). Food value of tomato is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). It is widely used in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. It is adapted to a wide range of climate from tropics to within a few degrees of the Arctic Circle. At present, tomatoes rank the third, next to potatoes and sweet potatoes, in terms of global vegetable production and the leading producing countries in the world are China, United States of America, India, Egypt, Turkey, Iran, Italy, Mexico, Brazil and Indonesia (FAO, 2002). Bangladesh grew tomato in around 15,700 hectares of land in the year 2007-2008 with a total production of approximately 143,000 tones (BBS, 2008). The average tomato yield in Bangladesh is quite low (6.82 t/ha) compared to other countries of South and Southeast Asia like India (17.00 t/ha), Pakistan (9.67 t/ha), Sri Lanka (7.57 t/ha) and Thailand (8.77 t/ha) (FAO, 2003). The low yield of tomato in Bangladesh is due to unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper irrigation facilities. Deficiency of soil nutrients now considered as one of the major constraints to successful upland crop production in Bangladesh. Reductions of organic matter as well as improper recycling of organic by-products affect soil fertility and productivity. Proper soil fertility management, therefore, is of prime importance in an endeavor to increase crop productivity.

It has been reported that nitrogen, phosphorous and potassium are the most important nutrient elements for satisfactory growth, development and also yield of tomato (BARC, 2005). In indeterminate type of tomato, vegetative and reproduction stages overlap and the plants need nutrients up to fruit ripening to get one ton fresh fruit (Hedge, 1997). Many horticultural crops are heavy removers of nutrients and high yields can only be sustained through the application of optimal doses in balanced proportion. In Bangladesh, fertilizer especially nitrogen is the most critical input for increasing production and had appropriately been recognized as the central element for agricultural development (Mukhopadhyay *et al.,* 1986). Solaiman and Rabbani (2006) reported that the highest plant height, dry weight of shoot, the maximum number of clusters of flowers, fruits per plant as well as the greatest fruit size and fruit yield per plant, fruit yield per ha of tomato were obtained from the application of the recommended dose of nutrients. Gupta and Sengar (2000) reported that N application on tomato resulted in increased plant height, number of fruits per plant, fruit weight and fresh yield. Nitrogen deficiency in the soil can result in stunted spindly growth and yellowing of leaves at the base of tomato plant and it can also turn younger leaves into smaller sizes and darker color, often puckered or curled (Needham, 1973). The deficiency of N can decrease the production of number of fruits, fruit size, storage quality, color, and taste of tomato. In addition, nitrogen is a constituent of protein and amino acids, without which vital functions in the growth and reproduction of plants would not be possible (Winsor, 1973). High N level in the soil, on the other hand, can promote excessive vegetative growth which can delay the setting and maturity of tomato fruits, thereby reducing tomato production (Kaniszewki and Elkner, 1990, Winsor *et al.,* 1967). Also, phosphorus helps to initiate root growth of tomato and therefore aids in early establishment of the plant immediately after transplanting or seeding. The vigorous root growth stimulated by P helps in better utilization of water and other nutrients in the soil and promotes a sturdy growth of stem and healthy foliage (Gould, 1983, Nelson, 1978). It helps in the production of large number of blossoms in the early growth of tomatoes and early setting of fruits and seeds (Zobel, 1966). It was reported that, P increases the number and production of tomato fruits, with increased total soluble solids and acidity contents (Adb Alla *et al.*, 1996). Reports also indicated that an increase in the concentration of N and P fertilizers increased the yield and yield components of tomato (Mehla *et al.*, 2000).

Among the major nutrients, potassium not only improves yields but also benefits various aspects of quality. It enhances storage and shipping quality of bananas, tomatoes, potatoes, onions and many other crops, and also extends their shelf life (Usherwood, 1985; Geraldson, 1985; Koo, 1985; Von Uexkll, 1985; Bhargava *et al.*, 1993 and Mengel, 1997). It helps in growth and development stimulates flowering and setting of fruits, thereby increasing the number and production of tomatoes per plant (Varis and George, 1985). It also increases the concentrations of citric and malic acids, total solids, sugars, and carotene in tomato fruits, thereby improving its storage quality (Von Uexkull, 1979). Increasing K rate up to 60 kg/ha increased growth parameters like plant height, and also increased fruit weight and marketable yield. The tomato yield, weight/fruit, fruits/plant and fertile pollen significantly increased when K fertilizer applied amount was properly increased. Adding K fertilizer at 150 kg/ha was proper to increase the pollen viability, yield and quality of tomato. The use of chemical fertilizers as supplemental sources of nutrients has been increasing steadily in Bangladesh, but they are usually not applied in balanced proportions by most of our farmers (Anonymous, 1997). Other essential plant nutrient sulfur is a constituent of protein and amino acid. Deficiency of S in the field is rare because it is usually applied in combination with N, P, and K fertilizers. Gypsum application resulted in tallest plants, shortest days to 50% flowering, largest fruits and highest number of fruits of tomato plant (Hamsaveni *et al.*, 2003). However, the application of the balance composition of different chemical fertilizers on changes of phonological development, yield and quality attributes of tomato is not yet clear.

It is well established that soil organic matter is an important factor for improving crop productivity. Available reports indicated that most soil in Bangladesh has low organic matter content usually less than 2% (Anonymous, 1997). Moreover, the organic matter content of Bangladesh soils is declining with time due to inadequate attention of the farmers. There are different sources of organic matter viz. cowdung, poultry manure, kitchen by-products, urban or municipal wastes, sewage sludge, vermicompost etc., which provide nutrients to the soils and by which the plants can uptake essential plant nutrients from soil. Cowdung is a good source of different plant nutrients particularly NPKS and judicious application of cowdung along with inorganic nutrients are helpful to obtain a good economic return. Saliou *et al.* (1999) reported that the cow and sheep manures showed more dry-matter to tomato fruit conferring them a longer shelf-life. These are suggestive that cowdung has profound effect on growth and yield of different crops.

It was also reported that combined effect of chemical fertilizers and organic matter like cowdung have profound effect on the growth and development of tomato as well as morphology, physiology and quality of plant. Gupta and Shukla (1997) suggested that NPK fertilizers regulate the growth, development and yield of tomato. Tomato can also be supplied with a combination of compost and mineral N fertilizers to improve fruit yield (Akanbi *et al.*, 2005). The application of recommended rates of NPK with farmyard manure and vermicompost was superior in terms of yield per plant, yield/ha, number of fruits per plant, average fruit weight, number of fruits per cluster, and TSS content (Shukla *et al.,* 2006). These findings suggest that the growth and yield of different crops increased with the additive application of inorganic and organic fertilizers. It recommended that the manure 9-18 tons/acre produced better yield and good quality tomato. Thus the production of vegetable including tomato through organic approach is increasing. However, the information is not enough to cultivate tomato with different sources of nutrition in Bangladesh.

This field experiment was conducted with the following objective:

> To find out the interaction effect of chemical fertilizers and cowdung on the phenology, yield and quality of tomato.

Chapter II

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

Phenology, yield and quality attributes of tomato as well as the growth and development are greatly influenced by the effects of chemical fertilizers and organic manures. Among these chemical fertilizers (nitrogen, phosphorous, potassium and sulphur) and organic manure (cowdung) are the most important nutrient elements for satisfactory growth, development and yield of tomato. A good number of research works have been conducted at home and abroad on the effects of chemical fertilizers and organic manures on phonological development, yield and quality attributes of tomato. Although extensive research have been carried out in the world on chemical fertilizers and organic manures, yet the work on comparative performances of chemical fertilizers and organic manures such as urea, TSP, MP, gypsum and cowdung are very limited particularly under Bangladesh perspectives. In this chapter, an attempt is made to review the available literature pertaining to the present study.

2.1 Effect of chemical fertilizers on the phenology, yield and quality of tomato

Salam *et al.* (2009) conducted an experiment at the vegetable research farm of the Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during the period of 2006-2007 to investigate the effects of boron and zinc in presence of different levels of NPK fertilizers on quality of tomato. The highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), acidity (0.47%), ascorbic acid (10.95 mg/100g), lycopene content (112.00μg/100g), chlorophyll-a(41.00μg/100g), chlorophyll-b (56.00μg/100g), marketable fruits at 30 days after storage (67.48%) and shelf life (16 days) were recorded with the combination of 2.5 kg B+ 6 kg Zn/ha and recommended dose of NPK fertilizers (N@ 253, P@ 90, and K@ 125 kg/ha).

Shaymaa *et al.* (2009) conducted a study to compare the effect of method and rate of fertilizer application under drip irrigation system were evaluated on growth, yield and nutrient uptake by tomato grown on sandy soil. Higher level of fertigation was found significantly concerning growth parameter and total fruit yields. Fertigation at 100% NPK recorded significantly higher total dry matter (4.85 t/ha) and LAI (3.65) respectively, over drip irrigation. The fruit yield of tomato was 28% higher in drip irrigation (43.87 t/ha) over furrow irrigation (34.38 t/ha). Fertigation with 100% NPK water-soluble fertilizers increased tomato fruit yield significantly (58.76 t/ha) over furrow irrigated control, drip irrigation, 50% fertigation (48.18 t/ha) and 75% NPK fertigation (54.16 t/ha).

Zhang *et al.* (2008) conducted an experiment arranged in a factorial design with four levels of N (0, 120, 240, and 360 kg N ha^{-1}) and three levels of P (0, 100, and 200 kg P_2O_5 ha^{-1}) and reported that fertilizer N application affected biomass yield of stems and leaves, total and marketable fruit yields, N use efficiency, and N agronomic efficiency. However, neither P application nor the interaction between fertilizer N and P influenced these variables. Nitrogen use efficiency and N agronomic efficiency decreased with increases in fertilizer N rate, with N use efficiency averaging 443 kg kg^{-1} and N agronomic efficiency averaging 237 kg kg^{-1}.

Oko Ibom, G. O. and Asiegbu, J. E. (2007) investigated the fruit quality characteristics of eight tomato (*Lycopersicon esculentum* Mill.) cultivars namely; UN-83, Nsukka Local, Roma VFN, Ronita, Ife-1, Rossol, NHle 7-7-1 and Ace VF were assessed under seven fertilizer application schemes in two field experiments at Nsukka, Southeast Nigeria. The tomato cultivars, UN-83, Roma VFN and Ronita excelled in most of the fruit quality characteristics studied, especially, resistance to cracking, low seed content, firmness, percent titratable acidity and soluble solids and longer shelf life.

Zhang *et al.* (2007) conducted field experiments with five rates (0, 75, 150, 225, and 450 kg P_2O_5 ha^{-1}) of seedbed P fertilizer application to investigate the yield of tomato in response to fertilizer P rate on calcareous soils with widely different levels of Olsen P (13-142 mg kg^{-1}) at 15 sites in some suburban counties of Beijing (China) in 1999. Under the condition of no P fertilizer application, tomato yield generally increased with an increase in soil test P levels, and the agronomic level for soil testing P measured with Olsen method was 50 or 82 mg kg^{-1} soil to achieve 85% or 95% of maximum tomato yield, respectively. With regards to marketable yield, in the fields where Olsen P levels were < 50 mg kg^{-1}, noticeable responses to applied P were observed.

Taiwo *et al.* (2007) conducted field trials in Ibadan, Nigeria, during 2002 and 2004 to evaluate the effect of fertilizer types on the yield and quality of tomato (*Lycopersicon esculentum* cv. Ibadan Local). The application of CBF alone increased fruit yield by 145% over the controls, and was superior to the other treatments in 2002. The application of CBF + urea to tomato affected the growth and quality of the fruit. The titratable acidity in tomato grown with CBF alone slightly decreased in relation to tomato treated with 30 kg NPK ha^{-1}, but the vitamin C increased by 13% and the Ca content increased by 44% than the controls.

Simonne *et al.* (2007) conducted an experiment in Spring 2005, tomatoes were grown on a Lakeland fine sand in North Florida using plasticulture and N rates @ 0, 78, 157, 235, 314, and 392 kg/ha. Soluble solid contents decreased as N rate decreased for the first harvest (8.1 to 5.6 for 0 to 392 kg/ha of N), but increased for the second harvest (6.9 to 10.1 for 0 to 314 kg/ha of N).

Segura *et al.* (2007) reported that the effect of different NPK doses applied by fertigation and two types of irrigation water on tomato production under greenhouse conditions. An increase of the nutrient concentration from 100 to 200% produced a slight increase of yield (less than 10%), but lowered the nutrient uptake efficiency (27% for N, 44% for P and 34% for K).

Qin and Li (2007) conducted a solar greenhouse trial with a cultivar Ershishiji Fenbao in 2003-04 to investigate the effects of different K applied amounts (300 as the control, 450 and 600) on its yield and quality during 2003-04. Adding K fertilizer @ 150 kg/ha was proper to increase the pollen viability, yield and quality of tomato based on custom fertilizer application pattern (45 m^3 chicken dung/ha., 600 kg N/ha., 300 kg P_2O_5/ha, and 300 kg K_2O /ha).

Podsiado *et al.* (2007) conducted field experiments during 1999-2001 in northwestern Poland, on sandy soil to assess the effect of drip irrigation and mineral fertilizer application on some features and yield of high bush and dwarf tomato (cvs. Kora and Betalux, respectively). NPK @ 340 kg/ha gave the largest fruit. Betalux yielded better than Kora by 41% of marketable fruit, and by 66% of the total crop. Fertilizer application significantly increased sclerenchyma width while other features changed only to some extent.

Elia *et al.* (2007) carried out an experiment with four levels of N (0, 100, 200 and 300 kg ha^{-1}) were applied through fertigation to evaluate the growth, N uptake, NUE, and yield of tomato. At harvest, the total and marketable yields were assessed. By applying 300 kg ha^{-1} of N, plants had higher dry mass yield (approximately 13.0 t ha^{-1}). Fresh matter, total, and marketable fruit yields increased from 0 to 100 and 200 kg ha^{-1} of N (6.6, 5.5 and 4.2 kg/plant, respectively), while with increasing levels, the same variables showed a decreasing trend. A greater number of total and marketable fruits per plant (160 and 109, respectively) were obtained upon supplying 200 kg ha^{-1} of N.

Deshmukh and Takte (2007) reported that the effects of fertigation on the performance of tomato (cv. Rajashree) were studied in Rahuri, Maharashtra, India. The application of 80% of the recommended rate through water-soluble fertilizers was superior to the other treatments. A 16% increase in yield (85.97 t ha^{-1}) was obtained with fertigation of 80% of the recommended fertilizer rates.

Jan *et al.* (2006) carried out a field experiment during summer 2004, at Karina Farm Juglote, Northern Areas of Pakistan, to study the impact of NP application in light textured soil on growth and yield of tomatoes and to develop more sustainable fertilization strategies. Maximum plant height (18.58 inches), number of branches $plant^{-1}$ (17.77), number of leaves $plant^{-1}$ (129.0), number of fruits $plant^{-1}$ (21.79), fruit weight (67.22 g), yield $plant^{-1}$ (1465 g) and yield ha^{-1} (43.95 tons) were recorded in treatments receiving N and P @ 110 and 100 kg ha^{-1}.

Kadam and Karthikeyan (2006) conducted an experiment at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India, during 1998-99 to study the yield, yield contributing characters and quality parameters of tomato cv. Dhanshree as affected by fertigation. The number of fruits and weight of fruits per plant were greatest in plants treated with 100% of the recommended NPK applied through drip (T4), 100% of the recommended NPK applied to soil + drip irrigation (T_2), and 70% N + 80% P and K fertigated through drip (T_5). Quality parameters, such as pH, TSS (total soluble solids) and lycopene content, under 100% of the recommended NPK applied.

Parisi *et al.* (2006) conducted an experiment to study the influence of nitrogen supply (from 0 to 250 kg N ha^{-1}) on yield and quality components of processing tomato grown in 2002-03 in Sele valley (Campania, Italy). Nitrogen fertilizer application from 50 to

250 kg/ha increased total yield but not marketable yield, because of a strong increase of unmarketable yield. Rates higher than 150 kg/ha did not produce increase in total, ripe and unripe yield.

Chaurasia *et al.* (2006) reported that the effects of the foliar application of Multi K and NPK (19:19:19, 19:9:19 or 17:10:27) in 3 or 5 times, in addition to the soil application of the recommended NPK rates, on the performance of tomato were studied in Varanasi, Uttar Pradesh, India, during 1999-2002. The greatest mean plant height (125.4 cm), number of branches per plant (4.2), fruit length (4.9 cm), fruit diameter (4.5 cm), number of fruits per plant (24.6), yield (745.12 quintal/ha) were obtained with spraying of 19:9:19 NPK 5 times. The highest TSS content (3.54%) was recorded for 17:10:27 NPK.

Tomar and Madhubala (2006) conducted a field experiment in Jhabua, Madhya Pradesh, India, during the rabi seasons of 2002-03 and 2003-04 to study the effects of planting date and N fertilizer (urea) @ (80, 100 or 120 kg/ha on the performance of tomato (*L. esculentum* cv. ACC-99). The highest fruit yields of 292.78 and 274.04 quintal/ha were obtained with planting during the last week of October and 2nd week of November in combination with the application of 116.82 and 132.41 kg N/ha, respectively.

Bharkad *et al.* (2005) conducted a field trial in Maharashtra, India, during 2002-03 to study the effects of different levels of Bio-K (0, 0.5, 1.0 and 1.5 ml/litre of water) and/or inorganic fertilizers (100% recommended dose of NPK (RDF), 100% NP + 75% K, 100% NP + 50% K, 100% NP + 25% K) on tomato cv. Parbhani Yashshri. The number of branches (9.66), number of flowers (83.93), fruit weight (47.01 g), total yield per plant equatorial diameter (4.40 cm), TSS (5%), were highest with treatment Bio-K @ 1.5 ml/litre of water + 100% NP + 75% K. The RDF recorded highest number of fruits (39.46) and fruit set (45.2%).

Yan DongYun and Zhang Mi (2005) reported in a pot experiment with tomato, 4 controlled-release compound fertilizers (CRCFs) with a controlled-release duration of 90 days, differing in the ratio of NPK, were compared with common compound fertilizer (CCF) containing the same amount of nutrients. CRCFs significantly increased plant height, leaf area, leaf number and fresh fruit weight compared with the control and were favourable for the prevention of diseases and pests.

Ingole *et al.* (2005) conducted a study in Akola, Maharashtra, India during kharif 2003 to evaluate the effect of NK fertilizers on the fruit yield and quality of tomato cv. Arkas Vikas. Maximum yield was obtained from 100 kg N/ha (31.14 t/ha). N @ 125 kg/ha produced the highest soluble solids content in fruits. N @ 125 kg/ha + K @ 25 kg/ha resulted in maximum titratable acidity.

Singh A. K. (2005) conducted an experiment during 1997-98, in Bichpuri, Agra, Uttar Pradesh, India, to evaluate the effects of spacing (75×50, 75×75 and 75×100 cm) and N level (0, 75, 150, 200 and 250 kg/ha) on tomato hybrid Naveen. The highest yield was obtained with the narrowest spacing and highest (250 kg/ha) nitrogen fertilizer level.

Singh *et al.* (2005) reported that the effects of NPK @ 200:100:150, 350:200:250 and 500:300:350 kg/ha on the growth and yield of tomato hybrids Rakshita, Karnataka and Naveen were determined in an experiment conducted in New Delhi, India during the early winter of 2000-02. Plant height, number of leaves per plant, leaf length, stem thickness, number of flower clusters per plant and picking period were highest with the application of 500:300:350 kg NPK/ha during both years. Fruit yield (30.2 and 3.48 kg/ha in 2000-01 and 2001-02, respectively) and number of pickings (14 during both years) were highest with the application of 350:200:250 kg NPK/ha.

Yang *et al*. (2005) conducted a pot experiment to determine the effects of potassium (K) fertilizer on yield, quality, and resistance of tomato to unfavorable environments in China. The results showed that the yield of tomato treated with K fertilizer increased by 15.71% more than that without K. Applying K promoted the absorption of N and increased the utilization ratio of NK fertilizer also improved the quality of tomatoes.

Bineeth *et al.* (2004) conducted a field experiment in Karnataka, India, to investigate the effects of graded levels of NPK on the yield, quality and nutrient uptake of tomato cultivars resistant to tomato leaf curl virus (TLB 111, TLB 130 and TLB 182). Among the interactions, TLB 182 with 150% RDF recorded the highest fruit yield (87 t/ha). As far as the quality is concerned, TLB 182 with 150% RDF showed higher rind thickness (0.74 cm), fruit size (32.47 cm^2) and pH 4.40. TLB 130 with 150% RDF showed the highest total soluble solids content (4.40%), acidity (0.48%) and ascorbic acid (46.87 mg/100 g juice). TLB 182 showed the highest N (121.29 kg/ha), phosphorus (11.74 kg/ha) and K (109.97 kg/ha) uptake with 150% RDF.

Groote *et al.* (2004) conducted an experiment to investigate the effects of NP rates on the growth of tomato (cv. Capita). The relative growth rate increased sharply with increasing plant P concentration, and then leveled off. The response of relative growth rate to increasing plant N concentration was gradual, leveling off at high N concentrations. This suggests that the 2 highest N rates were high enough to gain maximum growth.

Singh and Parmar (2004) conducted a study in Uttar Pradesh, India during 1996-97 to investigate the effects of N (0, 100, 200 and 300 kg/ha) designated as N1, N2, N3 and N4, and spacing designated as S_1, S_2 and S_3, respectively, on the biochemical components of tomato hybrids Naveen and Rupali. Naveen showed higher total soluble solids (TSS) content, ascorbic acid and acidity than Rupali, but Rupali showed higher juice and seed contents. Ascorbic acid content increased with increasing spacing. N2 produced the highest TSS, juice content and seed content (5.96, 62.46 and 180.83%, respectively) among the N rates.

Yagmur *et al.* (2004) conducted a study in Turkey to examine the effect of K fertilization on greenhouse tomato yield and quality parameters. Results showed that the highest dose of K yielded the highest. Similarly, the highest K dose was also positively effective on some fruit parameters as average fruit weight, fruit width, ten fruit weight and acidity. On the other hand, 240 K_2O ha^{-1} dose had positive impacts on total soluble solids, Vitamin C and color of fruits.

Bineeth *et al.* (2004) conducted an experiment during late summer season of 2000 at the Main Research Station, University of Agricultural Sciences, Bangalore on red sandy loam soil to study the effect of grade levels of fertilizers on growth of three tomato leaf curl resistant varieties. Among leaf curl resistant varieties TLB 182 recorded significantly higher plant height (81.83 cm), leaf area (117.51dm^2), leaf area index (2.17), total plant dry matter production (256.62g $plant^{-1}$), and crop growth rate (4.71g $plant^{-1}$ day^{-1}), fruit yield (87 ton ha^{-1}), net income (Rs. 181855/-) and cost benefit ratio (1:5.10) with 150% recommended dose of fertilizer.

Ashok *et al.* (2003) conducted a study to determine the optimum nitrogen (N) and phosphorus (P) rates for tomato hybrid production in Uttar Pradesh, India, during the 1991-93 rabi seasons. P hastened the first fruit picking compared with the control. The highest P rate hastened the final picking. The highest N and P rates recorded the highest increases in TSS and ascorbic acid. The highest mean yields of 538.8 and 592.1 q/ha in Rupali and Naveen, respectively, were recorded from the combined application of 180 kg N/ha + 120 kg P/ha.

Chandra *et al.* (2003) reported that the effects of N: P: K @ (200:100:150, 350:200:250 or 500:300:350 kg/ha on the performance of 4 indeterminate tomato hybrids (Rakshita, Karnataka, Naveen and Sun 7611) were studied in a multi-span greenhouse during 2000-2001 and 2001-2002. Among the fertilizer levels, N: P: K @ 350:200:250 kg/ha was superior in terms of fruit diameter, average fruit weight, yield, gross income and benefit: cost ratio. The number of fruits per plant increased with the increase in the rate of NPK.

Colla *et al.* (2003) carried out two field experiments during summer 2000 at the University of Tuscia in Central Italy to evaluate the impact of nitrogen fertigation rate on the growth, yield and fruit quality of processing tomato hybrids. In both experiments, total aboveground dry weight of aerial biomass, leaf area index (LAI) and yield increased with an increase in nitrogen rate.

Harneet *et al.* (2003) carry out an investigation in Punjab, India during 2000-01 to study the effect of NK application on the growth, yield and quality of spring crop of tomato cv. Punjab Upma. Significant increase in juice content, ascorbic acid content, N and K concentrations in leaves was observed when the N level increased from 100 to 140 kg/ha. There was also a significant increase in the concentration of K in leaves when K level was increased from 40 to 60 kg/ha.

Guvenc and Badem (2002) conducted greenhouse experiments to study the response of tomato cv. Sakata F1 178 to various sources and levels of N. The highest early yield (yield in 30 days) was obtained with urea (966.1 g per plant). The total yield was improved by ammonium nitrate and urea but not by potassium nitrate. Urea @ 0.6% gave the highest number of fruits per plant (76.5) and total yield (5196 g per plant).

Sahoo *et al.* (2002) conducted an experiment in Orissa, India during 1999-2000 with different levels of NK were tested to standardize the nutrient levels for growth and yield of tomato fruit. All the observations recorded in relation to yield and yield attributing characters indicates the superiority of N (150 kg/ha) over other treatments except single fruit weight (g). With each increase in levels of K from 75 to 150 kg/ha, a correspondingly significant decrease in the yield of tomato was observed.

Duraisami and Mani (2002) reported that the optimum levels of NPK for yield maximization of rainfed tomato and for sustained soil fertility were determined. All treatments recorded higher crop yield compared to the control, with 80 kg N/ha+40 kg P_2O_5/ha+80 kg K_2O/ha recording the highest yield (20.5 t/ha). TSS had an inverse relationship with N rates but increased with increasing P and K.

Khalil (2001) undertook a field study in Peshawar, Pakistan in the summer of 1995-96 to determine the appropriate nitrogen fertilizer for maximum tomato (cv. Peshawar Local) yield and its effects on various agronomic characters of tomato. The ammonium sulfate + P + K treatment was the best among all treatments with respect to days to flower initiation (57 days), days to first picking (94 days), weight of individual fruit (50.8 g), weight of total fruits per plant (1990 g) and yield (21,865 kg/ha).

Sharma *et al.* (2001) conducted a field experiment in Kullu, Himachal Pradesh, India, during 1996 and 997 to study the effect of N (0, 50, 100, 150, and 200 kg/ha) and spacing on the growth and yield of tomato. Fruit and seed yields, number of fruits per plant, plant height, fruit length, fruit diameter, and fruit weight increased with the increase in N rate. However, yields produced with 150 and 200 kg N/ha did not significantly vary. The increase in N rate delayed maturity.

Singh *et al.* (2000) conducted an experiment in Uttar Pradesh, India, to determine the suitable rate and application of N fertilizers for obtaining optimum growth and yield of tomato cv. N at 80 kg/ha applied in 3 splits produced the highest yield and biomass. Increasing N rates resulted in increasing biomass and yield.

Turemis, N. and Darin, K. (2000) conducted a research in the small fruits implementation area belonging to Cukurova University Agricultural Faculty Horticultural department, Turkey, during the 1999 vegetation period with Nessy, Chester Thornless, Oregon Thornless and Jumbo blackberry cvs. Pollen viability levels in these cultivars were determined by using TTC and FDA staining tests. In addition, the effects of 50, 100, 200 and 400 ppm concentrations of $Ca(NO_3)_2$, $MgSO_4$, KNO_3 and H_3BO_3 on pollen germination were investigated. Pollen viability levels varied from 79.75%

(Oregon Thornless) to 91.94% (Chester Thornless) in TTC, and 82.17% (Oregon Thornless) to 93.15% (Chester Thornless) in FIDA. The effects of minerals on pollen germination were found to vary according to cultivars and dose.

Begum *et al.* (2000) conducted a field experiment in the rabi season of 1998-99 on a clay terrace soil in Salna, Gazipur, Bangladesh to study the effects of irrigation and P fertilizer application on the yield, total water use, and water use efficiency of tomato (cv. Roma VF). In the individual effects of irrigation and P application, the yield was significantly high in the three and four irrigations and @ 120 kg P ha^{-1}.

Gupta and Sengar (2000) reported that tomato cv. Pusa Gaurav treated with N @ 0, 40, 80 and 120 kg/ha and K @ 0, 30 and 60 kg/ha in a field experiment conducted in Madhya Pradesh, India during rabi 1992-93 and 1993-94. N application resulted in increases in plant height, number of fruits per plant, fruit weight and fresh yield. Increasing N rate produced a corresponding increase in yield and yield components, except total soluble solids (TSS) content. K increased vegetative growth, yield and TSS (total soluble solid) content. Increasing K rate up to 60 kg/ha increased growth parameters like plant height, and also increased fruit weight and marketable yield.

Mehla *et al.* (2000) reported that the response of 3 tomato cultivars to 3 levels of NP fertilizers (50 kg N/ha + 30 kg P/ha, 100 kg N/ha + 60 kg P/ha and 150 kg N/ha + 90 kg P/ha) and 4 spacing (60 × 60, 60 × 45, 45 × 45 and 30 × 30 cm) was investigated during 1992 and 1993 in Haryana, India. An increase in the concentration of N and P fertilizers increased the yield and yield components of tomato. The highest values in most parameters were observed in 150 kg N/ha + 90 kg P/ha, including the highest total fruit yields of 384.5 and 360.6 q/ha during 1992 and 1993, respectively.

Ravinder *et al.* (2000) conducted experiments at Solan in 1996 and 1997, eight tomato hybrids (Meenakashi, Manisha, Menka, Solan Sagun, FT-5×EC-174023, EC-174023×EC-174041, Rachna and Naveen) were treated with four NPK combinations (100:75:55; 150:112.5:82.5; 200:150:110; 250:187.5:137.5 kg NPK ha^{-1}). The number of marketable fruits per plant and yield per plant were highest in Menka followed by Manisha. Of the fertilizers treatments, 200:150:110 kg N: P: K ha^{-1} produced the highest yields.

Nanadal *et al.* (1998) conducted field experiments from 1989 to 1991 in Haryana, India, using four levels of each of P and K with tomato variety Hisar Arun showed that increasing levels of phosphorus up to 50 kg P and potash up to 80 kg K /ha improved the height of plant, number of flowers, weight of fruit, early and total yield, ascorbic acid content, chlorophyll content, total soluble solids and reducing and non-reducing sugars in the fruit.

Rao, M. H. (1994) conducted in a field experiments on red sandy loam soil, the effects of K @ 0, 50, 100, 150, and 200 kg K_2O/ha as KCl or K_2SO_4 on growth, yield and quality of tomato cv. Arka Saurabh, carrot cv. Early Nantes and cauliflower cv. Aghani were examined. In tomato, mean fruit weight and total yield were significantly increased up to 100 kg K_2O/ha. However, there were no significant differences between K sources. The TSS, titratable acidity and ascorbic acid contents were increased as K increased.

2.2 Effect of cowdung on the phonology, yield and quality of tomato

Saliou *et al.* (2009) investigated the study to compare the effects of organic manures on tomato (*Lycopersicon esculentum* var. *Mongal*) by analyzing their impact on the yield, dry-matter, and the susceptibility of tomato under pesticide free condition. The poultry and groundnut manures recorded the highest losses due to damages by *H. armigera* respectively 13.3 and 13.2t/ha. The horse and fish manures were the least affected by the pest (9.7 and 10.1t/ha) and therefore recorded the highest net yields respectively 20.7 and 17.7 t/ha. However, the cow and sheep manures showed more dry matter to tomato fruit conferring them a longer shelf life. The horse dung based-fertilizer is highly recommended in tomato farming in the sahelian agro ecosystems.

Zhai *et al.* (2009) evaluated against conventional hydroponic fertilizers in two experiments with greenhouse tomatoes grown in peat based substrate with organic fertilizer regimens consisting of combinations of composts (yard waste, swine manure, or spent mushroom substrate) and liquid fertilizers (fish or plant based). In general, organic tomatoes had a lower postharvest decay index (better shelf life) than did the hydroponic controls, possibly as an indirect consequence of overall reduced yield in those treatments.

Periasamy A. (2009) carried out an experiment to assess the effect of egg lime mix with panchakavya on the growth and yield parameters of tomato plant (*Solanum lycopersicum*). Maximum height (34.6cm), leaf number (124.3/ plant), leaf area (10.6 cm^2), fruit number (17.8/ plant), fruit weight (34.2gm/ fruit) and total chlorophyll content (3.86 mg/g fresh wt) were observed in the plants treated with T4 formulations.

Qingren *et al.* (2008) conducted a field experiment to evaluate the effects of summer cover crops and organic compost on winter fresh market tomato (*Lycopersicon esculentum.*) yields and quality. The tomato total marketable yields increased 49-82 and 71-85 t/ha, respectively, in 2 year. The application of OM @ 75 or 50 t/ha increased tomato yields compared with that @ 25 t/ha. Yields of extra-large tomato fruits, especially at the first harvest during the early winter, were improved by growing sun hemp or applying the composts.

Sable *et al.* (2007) reported that the effects of various organic amendments on the performance of tomato (cv. Parbhani Yashshri) were studied in Parbhani, Maharashtra, India, during the rabi season of 2002-03. The organic manures were generally superior to the inorganic fertilizers in the enhancement of the pollen viability (%), the fruit yield and dry matter yield. The percentage of marketable fruits was higher when organic amendments were applied (83-93%) than when inorganic fertilizers were used (77.5%). The fresh fruit weight was lower when 100% of the N was supplied through vermicompost than when N was supplied through various combinations of neem cake and vermicompost.

Togun *et al.* (2004) reported that the potentials of different plant residue composts as organic fertilizer on the growth, nutrient uptake, yield and economic performance of tomato were studied in Nigeria, during 1998 and 1999. The plant residues used were maize (Ms), guinea grass (Gg) and cowpea stover (Cs). Compost rate had a significant effect on the growth, nutrient uptake and yield of tomato. In most cases, the application of 4 ton compost/ha produced the best results. The fruit yield of 18.5 t/ha produced from the use of 4 t/ha compost was significantly higher than 14.1 and 14.4 t/ha obtained with application of 6 ton compost/ha and conventional NPK fertilizer, respectively.

Krishna and Krishnappa (2002) reported that the effect of NPK fertilizer applied with or without organic manures (farmyard manure and Agrimagic) on the yield and quality of tomato cv. Avinash-2 was investigated during rabi 2000/01 in Bangalore, Karnataka, India. In general, NPK @ 250:250:250 kg/ha plus Agrimagic @ 16.87 t/ha or farmyard manure @ 38 t/ha recorded the highest values for the different yield (plant height, branches per plant, clusters per plant, fruits per cluster, fruits per plant, fruit weight, fruit weight per plant, estimated fruit yield and total chlorophyll) and quality (pericarp thickness, fruit firmness, total soluble solids and titratable acidity) parameters.

Saliou *et al.* (1999) conducted a study to compare the effects of organic manures on tomato (*Lycopersicon esculentum* var. Mongal) by analyzing their impact on the yield, dry-matter, and the susceptibility of tomato in Niayes area (Senegal) under pesticide free condition. The overall yield varied between 30.4t/ha with the horse dung treatment and 24.5t/ha with the untreated. The poultry and groundnut manures recorded the highest losses due to damages by *H. armigera* respectively 13.3 and 13.2t/ha. The horse and fish manures were the least affected by the pest (9.7 and 10.1t/ha) and therefore recorded the highest net yields respectively 20.7 and 17.7 t/ha. However the cow and sheep manures showed more dry-matter to tomato fruit conferring them a longer shelf-life. The horse dung based-fertilizer is highly recommended in tomato farming in the sahelian agro-ecosystems.

Kumaran *et al.* (1998) reported that the effect of inorganic and organic fertilizers on growth, yield and quality of tomato was investiagted at Coimbatore, India. Results showed that a combination of organic and inorganic fertilizers gave the best results in terms of growth and yield. Plant height, branches/plant, mean fruit weight and number of fruits/plant were best with organic + inorganic fertilizers and *Azospirillium* and *phosphobacteria*. The quality parameters such as chlorophyll content, TSS, ascorbic acid and lycopene contents were comparatively higher in organically grown tomato plants.

2.3 Interaction effect of chemical fertilizers and manure on the phonology, yield and quality of tomato

Hala K. and Nadia G. (2009) carried out a field experiment in the Research and production station of National Research Centre at El-Nobaria during the season 2008 to evaluate the vegetative growth, yield quantity and quality of tomatoes as affected by different organic fertilizers and sulphur addition. Chicken manure and farmyard manure had a synergistic effect on both fresh and dry weights of tomato shoots and roots, yield quantity and quality as well as mineral composition of tomato fruits compared to control (mineral NPK).

Ayeni *et al.* (2009) conducted field experiments in two locations at Owo in southwest Nigeria in early and late crop seasons (2007) to compare the effects of poultry manure @ 0, 10, 20, 30, 40 t ha^{-1} and 300 kg ha^{-1} NPK 15:15:15 fertilizer on nutrient uptake and yield of tomato in randomized complete block design. Poultry manure @ 20, 30 and 40 t ha^{-1} and NPK 15:15:15 fertilizer significantly ($P<0.05$) increased plant leaf, area height, number of leaves, branches, fruits and fruit yield.

Adekiya A. O. and Agbede T. M. (2009) conducted four field trials during the years 2006 and 2007 at Owo, the forest- savanna transition zone in southwest Nigeria, to study the effect of poultry manure (PM), NPK 15-15-15 fertilizer and NPK 15-15-15 fertilizer + poultry manure on the growth and yield of tomato. All levels of poultry manure, NPK 15-15-15 fertilizer alone and NPK 15-15-15 fertilizer + poultry manure increased the number of leaves, plant height, leaf area, number of fruits and fruit weight significantly. Among poultry manure levels, 30 t ha^{-1} poultry manure gave the highest fruit yield. Among the seven treatments, NPK 15-15-15 fertilizer + poultry manure gave the highest yield.

Premsekhar, M. and Rajashree, V. (2009) conducted field experiments to study the effect of various biofertilizers on the growth, yield parameters, yield and quality of tomato var. CO_3. The results revealed that significantly taller plants, better yield parameters and higher yield was recorded with the application of *Azospirillum* + 75% N + 100% PK followed by *Azospirillum* + 100% NPK. The higher total soluble solids of 4.450 Brix were recorded with *Azospirillum* + 75% N + 100% PK.

Yoldas *et al.* (2009) conducted the study to determine the effects of organic and inorganic-fertilizer doses on yield and quality in processing tomato. Organic and inorganic fertilizer significantly increased total yield, fruit diameter and length, and average weight of tomato compare to control. The highest total yield, fruit diameter and length, average weight of tomato value were obtained at 6 t/da organic manure and half of recommended rate of inorganic fertilizer.

Olaniyi J. O. and Ajibola A. T. (2008) conducted field experiments to determine the effects of inorganic and organic fertilizers application on the growth, yield and nutrient content of tomato at the Ladoke Akintola University of Technology, Nigeria in the cropping seasons of 2004 and 2005. The yield and quality of tomato fruits produced with poultry manure are comparable with those obtained using mineral N fertilizer. Poultry manure can therefore be a suitable replacement for inorganic fertilizer in tomato production.

Ojeniyi *et al.* (2007) reported that combined use of crop and animal wastes is necessary in order to obtain adequate amount of organic manure for use in crop production. Among eight treatments compared, CH and SG amended with PM gave height fruit yield, compared with control, NPKF, amended SG and CH increased fruit yield by 268, 342 and 397%, respectively.

Dhanasekaran and Bhuvaneswari (2007) conducted a field experiment in a silty clay loam soil, in Tamil Nadu, India, to study the response of tomato to different levels of NPK and foliar application of enriched humic substances. The results revealed that foliar application of micronutrients and NAA enriched PCA to the plants supplied with 125% NPK recorded the highest fruit yield at the same level without causing any nutrient depletion in postharvest soil quality.

Shukla *et al.* (2006) conducted an experiment in farmers' fields of Solan district, Himachal Pradesh, India, during 2002-03 and 2003-04 to study the effects of inorganic and organic fertilizers on the performance of tomato. The application of recommended rates of NPK (100, 75 and 55 kg/ha, respectively) with farmyard manure and vermicompost (250 and 12.5 quintal/ha, respectively) was superior in terms of yield per plant, yield/ha, number of fruits per plant, average fruit weight, number of fruits per cluster, total chlorophyll content and TSS (total soluble solids) content.

Raut *et al.* (2006) carried out a field study at the Vegetable Research Farm, Maharajpur, Madhya Pradesh, India, during 1998-99 to determine the microbial population and the yield of tomato variety Jawahar Tomato-99, as affected by different nutrient sources. The recommended NPK along with FYM gave the maximum plant height (95.67 cm), fruit weight (591.0 g/plant) and fruit yield (196.43 q/ha) which shows promise on inorganic fertilizers.

Solaiman and Rabbani (2006) carried out a field experiment at the Bangabandhu Sheikh Mujibur Rahman Agricultural University farm, in Bangladesh, to assess the effects of inorganic and organic fertilizers on vegetative, flowering and fruiting characteristics as well as yield attributes and yield of Ratan variety of tomato. The highest plant height and dry weight of shoot, the maximum number of clusters of flowers and fruits/plant as well as the greatest fruit size and fruit yield/plant, fruit yield/ha were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K+15 kg S/ha, but similar results were obtained from the treatment receiving 5 ton cow dung/ha along with half of the recommended doses of nutrients (100 kg N + 17.5 kg P + 40 kg K + 7.5 kg S/ha).

Itoo and Manivannan (2004) conducted pot experiments to determine the effect of macro and micronutrients in different forms compared to humic acid on the growth, yield and quality of tomato. The treatments comprised: 10, 15 and 20 g Biogran/pot; 10, 15 and 20 tablets Biotab/pot; 20, 40 and 60 ppm NPK + humic acid/pot; and NPK fertilizer (control). Biotab @ 20 tablets/pot resulted in the maximum number of primary branches, number of flower clusters per plant and number of flowers per cluster, maximum number of fruits per plant, fruit yield per plant and single fruit weight , and TSS, ascorbic acid content and acidity.

Patil *et al.* (2004) stated that the effects of inorganic and organic fertilizers on the fruit yield and quality of tomato (cv. Parbhani Yashshri) were studied in Parbhani, Maharashtra, India, during rabi 2000/01. The application of 50% RFR + 50% FYM resulted in the greatest plant height (120.70 cm), number of primary branches per plant (8.53), number of fruits per plant (52.0), average fruit weight (45.06 g), yield per plant (2.34 kg), total chlorophyll content (0.132 mg g^{-1} fw) and total soluble solid content (6.08%).

Raut *et al.* (2003) conducted studies with tomato in Jabalpur, Madhya Pradesh, India, during 1998/99, involving 12 treatments: a control (T0), 100:50:50 kg NPK+20 tonnes farmyard manure (FYM) (T_1), 75 kg N+25 kg P+25 tonnes FYM (T_2), 70 kg K+10 tonnes poultry manure (PM) (T_3), 50 kg N+25 kg P+2.5 tonnes vermicompost (VC) (T_4), 10 kg P+20 FYM+5 tonnes PM (T_5), 22 tonnes FYM+1.5 tonnes VC (T_6), 90 kg K+7.5 tonnes PM+1 tonne VC (T_7), 30 tonnes FYM+5 kg *Azospirillum* (T_8), 20 tonnes PM+5 kg *Azospirillum*+5 kg phosphate solubilizing bacteria (PSB) (T_9), 3 tonnes VC+5 kg *Azospirillum*+5 kg PSB (T_{10}), and 5 kg *Azospirillum*+5 kg PSB (T_{11}). The maximum plant height (45.67 cm), number of branches (12.52), number of flowers per cluster (5.56), number of flower cluster per plant (32.88), fruit weight per plant (591 g) and fruit yield (196.43 q/ha) were recorded with T_1. The maximum number of fruits per plant (20.96) was recorded with T_9.

Togun *et al.* (2003) reported that the influence of maize-stover compost and N fertilizer on the growth, nutrient uptake and fruit yield of tomato was studied during 1997/98 and 1998/99 in Ibadan, Nigeria. Application of maize stover compost and N fertilizer enhanced plant growth. Plant height, number of flowers, dry matter yield and number of fruits per plant were significantly improved by the different levels of compost with or without N fertilizer.

Rafi *et al.* (2002) conducted the study on the effect of organic and inorganic fertilizers on yield and quality of tomato (cv. Parbhani "Yashashri") conducted in Parbhani, Maharashtra, India, revealed that application of 50% recommended dose of farmyard manure (FYM) @ 12.5 t ha^{-1} along with reduced levels of recommended doses of fertilizers (50% of the recommended dose of fertilizers of 100:50:50 NPK kg ha^{-1}) resulted in the highest yield with high quality.

Naidu *et al.* (2001) conducted an experiment during the 1996/97 and 1998/99 rabi seasons in Jabalpur, Madhya Pradesh, India, the use of organic and inorganic fertilizers with and without biofertilizers. Application of 100 kg N + 50 kg P_2O_5 + 50 kg K_2O+20 t FYM/ha was significantly superior than the other combinations and gave maximum plant height (50.68 cm), number of leaves per plant (49.50), number of branches per plant (16.83), number of flower clusters per plant (19.25), number of fruits per plant (25.67 q/ha), and yield (218.65 q/ha).

Chapter III

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter describes the materials used and methods of the experiment conducted in the field and in the laboratory to study the phenology, yield and quality of tomato *(Lycopersicon esculentum)* with different doses of fertilizers and cowdung. The field experiment was carried out in the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, under the agro-ecological zone of Modhupur Tract (AEZ No. 28) during the period from November 2008 to April 2009. The materials and methods that were used and followed respectively for conducting the experiment have been presented under the following headings:

3.1 Experimental site

The study was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The location of the experimental site was $23^0 74^{\prime}$N latitude and $90^0 35^{\prime}$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989). The map and experimental plot showing the experimental site under study is shown in Appendix III & IV.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under the AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot have been presented in Appendix I.

3.3 Climatic condition of the experimental site

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.4 Planting materials

Determinate type tomato variety BARI Tomato-6 (Chaiti) seedlings of 30 days were used. The seedlings of tomato were grown at the nursery of Sher-e-Bangla Agricultural University Farm.

3.5 Treatment of the experiment

The experiment consisted of two factors. Details have been presented below:

Factor A: Four levels of chemical fertilizers:

i. F_0: No chemical fertilizers (Control)

ii. F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha

iii. F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha

iv. F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

Factor B: Three levels of cowdung:

i. C_0: No cowdung (Control)

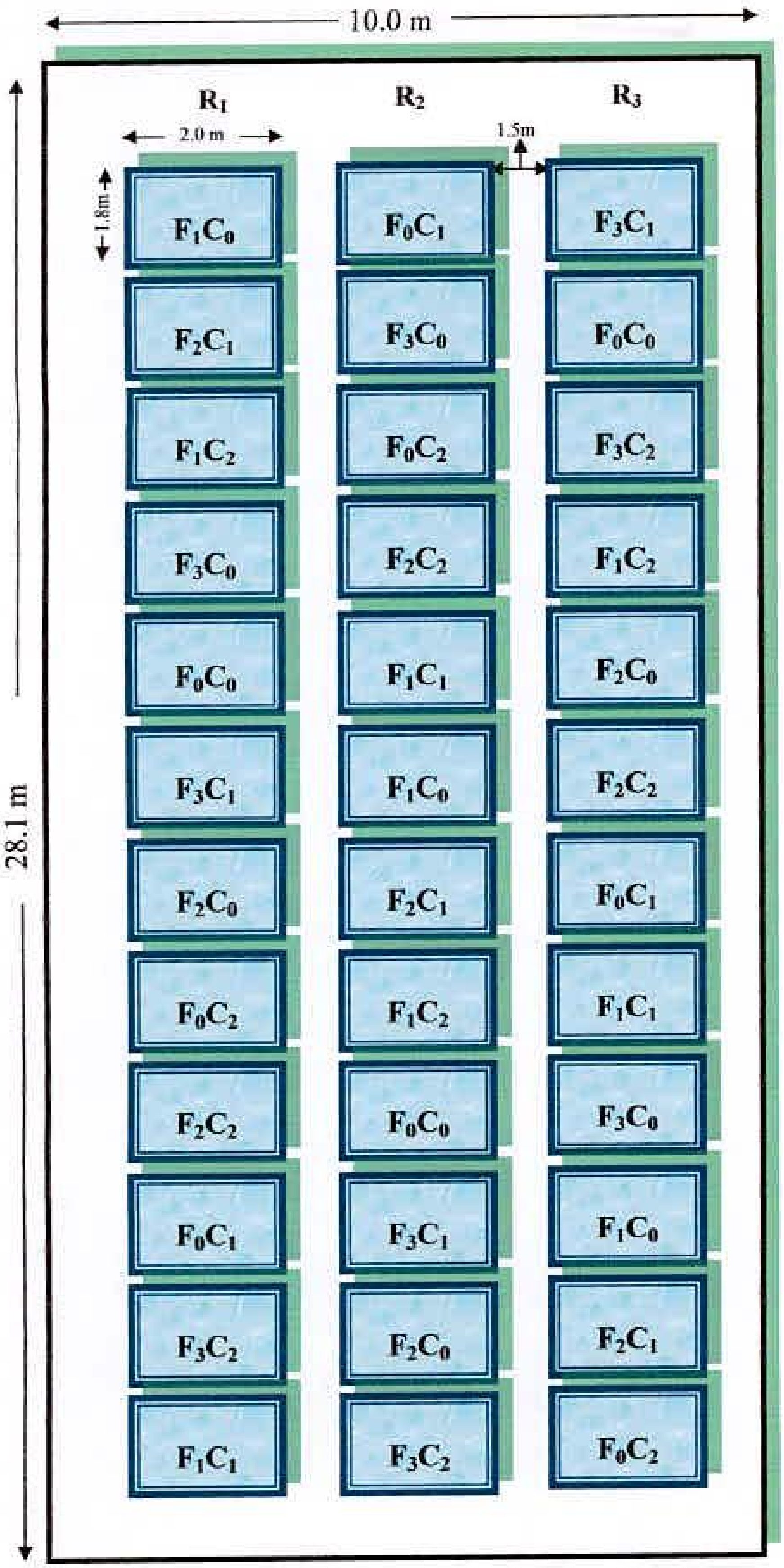
ii. C_1: 5 ton cowdung/ha

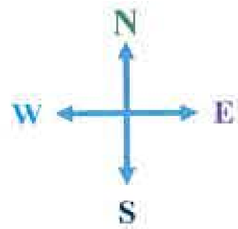
iii. C_2: 10 ton cowdung/ha

There were 12 (4 × 3) treatments combinations such as F_0C_0, F_0C_1, F_0C_2, F_1C_0, F_1C_1, F_1C_2, F_2C_0, F_2C_1, F_2C_2, F_3C_0, F_3C_1 and F_3C_2.

3.6 Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot was 2.0 m × 1.8 m. There were 36 unit plots altogether in the experiment. The distance maintained between two blocks and two plots were 1.5 m and 0.5 m, respectively. Plants were transplanted in the plot maintaining 60 cm and 50 cm distance between row to row and plant to plant, respectively. The layout of the experiment has been shown in Figure 1.





Plot size: 2.0 m × 1.8 m, **Plot spacing:** 50 cm, **Between replication:** 1.5 m, **Plant spacing:** 60 × 50 cm

Factors A:

F_0: F_0: No chemical fertilizers (Control)

F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha

F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha

F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

Factors B:

C_0: C_0: No cowdung (Control)

C_1: 5 ton cowdung/ha

C_2: 10 ton cowdung/ha

Figure 1. Layout of the experimental plot

3.7 Raising of seedlings

Tomato seedlings were raised in a seedbed of 3 m × 1m size. The soil of the seedbeds was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed carefully from the seedbeds and 5 kg well rotten cowdung was mixed with the soil. 10 gram of seeds was sown on each seedbed on 05 November 2008. After sowing, seeds were covered with light soil. Heptachlor 40 WP was applied @ 4 kg/ha, around each seedbed as precautionary measures against ants and worms. The emergence of the seedlings took place within 5 to 6 days after sowing. Weeding, mulching, irrigation, drainage and shading were done as and when required depending upon the necessity of the seedbeds.

3.8 Land preparation

Experimented plots were opened in the last week of November 2008 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good tilth. Weeds and stubbles were removed, and finally a desirable tilth of soil for transplanting tomato seedlings. The experimental plot was partitioned into unit plots in accordance with the design mentioned in Figure 1. Organic and inorganic manures as indicated below were mixed with the soil of each unit plot.

3.9 Application of manure and fertilizers

The sources of N, P_2O_5, K_2O and S as urea, TSP, MP and gypsum were applied in each treatment. The entire amounts of TSP, MP and sulfur were applied during the final land preparation. Urea was applied in three equal installments at 15, 30 and 45 days after seedling transplanting. Well-rotten cowdung was also applied during final land preparation as per requirement in each treatment.

3.10 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 03 December, 2008 maintaining a spacing of 60 cm × 50 cm between the rows and plants, respectively. This allowed an accommodation of 12 plants in each plot. The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect the seedling from the direct sunlight and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.11 Intercultural operation

After transplanting of seedlings, various intercultural operations such as irrigation, weeding and top dressing of urea fertilizers and pesticides etc. were accomplished for better growth and development of the tomato seedlings.

3.11.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after transplanting of seedlings and continuing watering in every alternate day in the evening upto establishment of seedlings. Further irrigation was provided whenever needed.

3.11.2 Stacking

When the plants were well established, stacking was provided to each plant by bamboo sticks to keep them erect.

3.11.3 Weeding

Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully.

3.11.4 Top dressing

After basal dose, the remaining doses of urea were used as top-dressed in 3 equal installments at 15, 30 and 45 DAT. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Earthing up operation was done immediately after top-dressing with nitrogen fertilizer.

3.12 Plant protection

Malathion 57 EC was applied @ 2 ml L^{-1} against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly from a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil treatment.

During foggy weather, precautionary measures against disease infestation of tomato was taken by spraying Dithane M-45 fortnightly @ 2 g/L, at the early vegetative stage. Ridomil Gold was also applied @ 2 g/L against blight disease of tomato.

3.13 Harvesting

Fruits were harvested at 3 days intervals during early ripening stage when they attained slightly red color. Harvesting was started from 22 February 2009 and was continued up to 02 April 2009.

3.14 Data collection

Five plants were randomly selected from each unit plot for the collection of per plant data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.14.1 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest stem (branch) and mean value was calculated. Plant height was also recorded at 10 days interval starting from 20 days of planting upto 60 days.

3.14.2 Number of leaves per plant

Data were recorded as the average of 10 plants selected at random from the inner rows of each plot from 20 DAT to 60 DAT at 10 days intervals.

3.14.3 Number of branches per plant

Data were recorded as the average of 10 plants selected at random from the inner rows of each plot from 20 DAT to 60 DAT at 10 days interval.

3.14.4 Days required to 1^{st} flowering from transplanting

Days from transplanting to initiation of flowering was counted from the date of transplanting to the initiation of flowering and was recorded as treatment wise.

3.14.5 Days required to 1^{st} harvesting from transplanting

Days from transplanting to 1^{st} harvesting was counted from the date of transplanting to the harvesting of fruits at first time and was recorded as treatment wise.

3.14.6 Number of flower clusters per plant

The number of flower clusters was counted from the sample plants and the average was calculated.

3.14.7 Number of flowers per cluster

The number of flowers was counted from the sample plants and the averaged.

3.14.8 Number of flowers per plant

The number of flower per plant was counted from the sample plants and the average was recorded.

3.14.9 Number of fruits per cluster

The number of fruits per cluster was counted from the sample plants and the average number of fruits per clusters was recorded.

3.14.10 Number of fruits per plant

The number of fruit per plant was counted from the sample plants and the average was recorded.

3.14.11 Fruit length

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 plot and average was taken in cm.

3.14.12 Fruit diameter

Diameter of fruit was measured at the middle portion of 10 selected marketable fruit from each plot with a slide calipers and average was taken in cm.

3.14.13 Weight of individual fruit

Among the total number of fruits collected during the period from first to final harvest of the fruits, except the first and final harvest, remaining fruits were considered for determining the individual fruit weight by the following formula:

$$\text{Weight of individual fruit} = \frac{\text{Total weight of fruit}}{\text{Total number of fruits}}$$

3.14.14 Yield per hectare

Yield per hectare of tomato fruits was calculated by converting the weight of plot yield into hectare and was expressed in $tonha^{-1}$.

3.14.15 Dry matter content in plant

After harvesting, randomly selected 150 g plant sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 60^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents of plant were computed by simple calculation from the weight recorded by the following formula:

$$\%\ \text{Dry matter content of plant} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100 \quad (g)$$

3.14.16 Pollen viability

Pollen viability i.e. viable and non-viable pollen was determined by the following procedure: Flower samples for the pollen analyses were randomly collected between 10:30 and 11:30 am. The pollens were divided into classes on the basis of shape and rate of the polar axis of the pollens in equatorial and polar views to the equatorial diameter (Erdtman, 1966). To determine viability level of pollens, 100 pollen grains of each group were counted under a light microscope. The level was determined with 2, 3, 5-triphenyl tetrazolium chloride (TTC) solution (Norton, 1966). One drop of this solution was placed on a slide and pollens were spread and a cover slip was placed on it. Counting was made after TTC application and it was divided into three groups based on staining density. Dark red stained pollens were referred as viable, light red as semi-viable and unstained as non-viable (Eti, 1991 and Stosser, 1984).

3.14.17 Shelf life

Shelf life of tomato was measured by keeping room temperature in a room and by using earthen pot and expressed in days.

3.14.18 Total soluble solid (TSS)

This is measured using a refractometer, and is referred to as the degrees Brix. It is widely used during fruit and vegetable processing to determine the concentration of sugar in the products. Sugar concentration is expressed in degrees Brix. Unit % and procedure is the soluble solids content of a solution was determined by the index of refraction. The measurement must be made at 20^0C to get an accurate value.

3.15 Statistical analysis

The data obtained for different characters of tomato plant were statistically analyzed to find out the significance of the difference for different levels of chemical fertilizers and cowdung on the phenological development, yield and quality of tomato. The statistical analysis was completed following MSTAT-C programme. The significance of the difference among the means of the treatment combinations was estimated by LSD (Least Significance Difference) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained due to the application of different doses of chemical fertilizers and cowdung on the phenology, yield and quality of tomato. Data on phenology, yield and quality attributes of tomato were recorded and the analyses of variance (ANOVA) of the data are presented in Appendix XVIII-XXIV. The results have been presented and discussed with necessary suggestions under the following headings:

4.1 Phenological characteristics

4.1.1 Plant height

Plant height is an important morphological character that acts as an indicator of availability of growth sources in its vicinity. The chemical fertilizers ensured favorable condition for the growth of tomato plant with optimum vegetative growth and resulted in tallest plants. In this study, plant height of tomato varied significantly due to the application of different levels of chemical fertilizers at 30, 40, 50, 60 DAT and harvest (Figure 2 and Appendix XVIII). The tallest plants in each harvest (25.80 cm, 44.16 cm, 61.34 cm, 81.89 cm and 117.58 cm) were recorded from the treatment F_2, which was followed by the treatments F_1 (24.92 cm, 43.51 cm, 59.50 cm, 77.99 cm). Besides, the shortest plants (23.27 cm, 41.60 cm, 57.02 cm, 74.74 cm and 109.60 cm) were obtained from F_0 (control) treatment. These results suggest that higher doses of chemical fertilizers increased plant height in tomato. In addition, the greatest plant height (125.4 cm), number of branches per plant (4.2), yield (745.12 quintal/ha) was observed by Chaurasia *et al.* (2006). These results are not in conflict with the findings of Tomar and Madhubala (2006) and Singh and Parmar (2004).

Plant height showed statistically significant variation due to different doses of cowdung at 30, 40, 50, 60 DAT and harvest (Figure 3, Appendix XVIII). In this study, the tallest plants (26.09 cm, 44.79 cm, 61.53 cm, 82.82 cm and 119.92 cm) were observed from the treatment C_2 (10 ton cowdung/ha) while the shortest plants (22.01 cm, 40.24 cm, 55.39 cm, 70.07 cm and 105.02 cm) were obtained from the treatment C_0. Periasamy (2009) found that maximum plant height (34.6cm), leaf number (124.3/ plant) were recorded from the plants treated with egg lime mix. These results indicated that elevation of cowdung increases plant height of tomato, which were supported with many reports.

Due to interaction effect of different levels of chemical fertilizers and cowdung in terms of plant height of tomato at 30, 40, 50, 60 DAT and harvest showed statistically significant variation (Table 1 & Appendix V, VI, and VII). The tallest plants (28.06 cm), (64.80 cm), and (127.04 cm) were found from F_1C_2 treatment at 30, 50 DAT and final harvest, respectively. On the other hand, the shortest plants (20.45 cm, 38.29 cm, 53.32 cm) were found from control treatments, where no application of any fertilizers and manure. These results are agreed with Krishna and Krishnappa (2002).

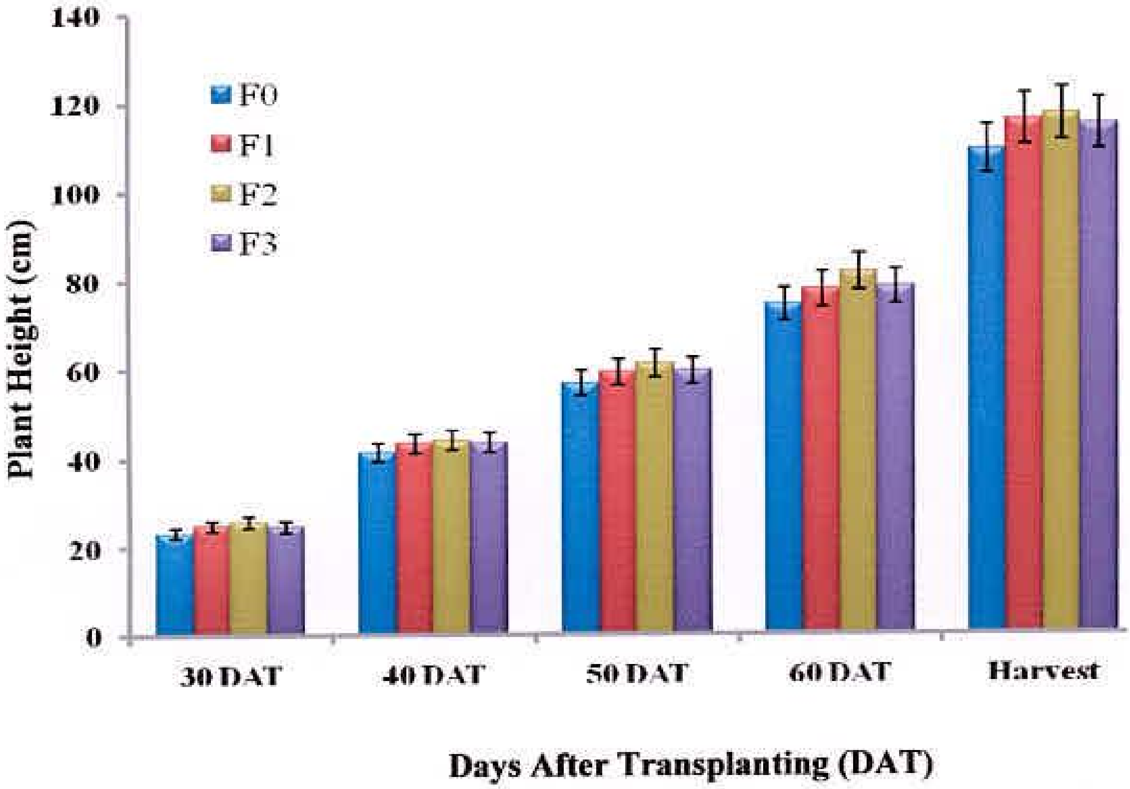


Figure 2. Effect of chemical fertilizers on plant height of tomato

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

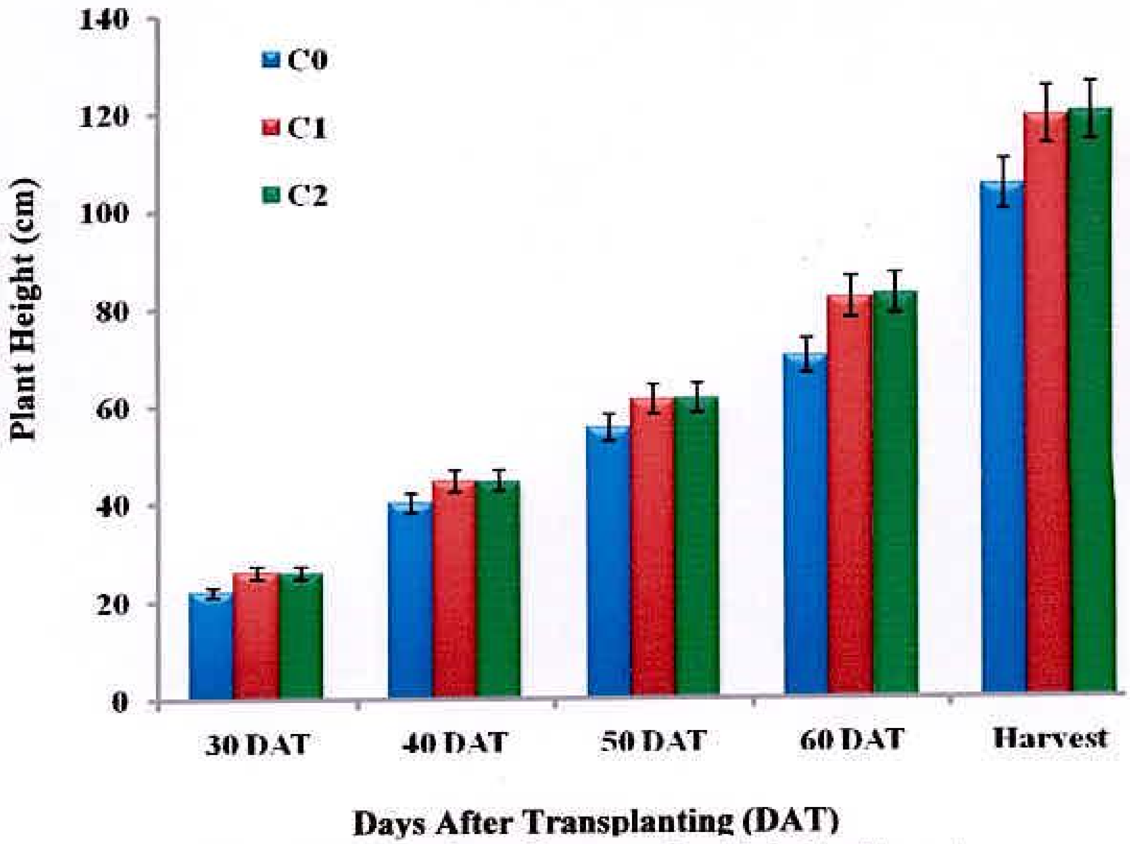


Figure 3. Effect of cowdung on plant height of tomato

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

Table 1. Interaction effect of chemical fertilizers and cowdung on plant height of tomato

Treatments (F×C)	Plant height (cm) at				
	30 DAT	40 DAT	50 DAT	60 DAT	Harvest
F_0C_0	20.45 g	38.29 h	55.35 de	65.32 g	112.14 ef
F_0C_1	25.52 bcd	44.25 bcd	61.18 bc	82.50 ab	115.24 de
F_0C_2	23.84 def	42.26 def	56.57 d	76.41 d	101.42 h
F_1C_0	21.99 fg	39.99 gh	53.32 e	69.38 fg	105.64 gh
F_1C_1	24.73 cde	43.66 cde	58.36 cd	77.28 cd	116.17 cde
F_1C_2	28.06 a	46.18 ab	64.80 a	86.20 ab	127.04 a
F_2C_0	23.17 ef	41.00 fg	57.36 d	74.71 de	108.08 fg
F_2C_1	27.34 ab	46.88 a	64.79 a	84.74 ab	123.87 ab
F_2C_2	26.88 ab	45.29 abc	62.97 ab	87.31 a	120.79 bcd
F_3C_0	22.43 f	41.67 efg	55.54 de	70.86 ef	104.94 gh
F_3C_1	26.26 abc	44.47 bc	61.90 ab	83.82 ab	121.28 bc
F_3C_2	25.59 bcd	44.74 abc	61.79 ab	81.36 bc	119.71 bcd
$LSD_{(0.05)}$	**1.783**	**1.987**	**2.832**	**4.438**	**5.438**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV (%)	**4.27**	**4.71**	**6.82**	**5.35**	**8.80**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.1.2 Number of leaves per plant

It is suggested that different doses of chemical fertilizers influence the growth of tomato plant, including number of leaves (Raut *et al.* 2003). The present experimental results showed that different composition of fertilizers significantly affect on number of leaves of tomato at different DAT and up to harvest (Figure 4 and Appendix XIX). At 30, 40, 50, 60 DAT and harvest, the maximum number of leaves per plant were obtained from the treatment F_2 (9.10, 22.46, 36.98, 47.67 and 63.31) whereas the minimum number was observed from the treatment F_0 (8.16, 19.48, 31.52, 41.22 and 51.96). The findings of this study were agreed with Raut *et al.* (2003).

Statistically significant variation was recorded in terms of number of leaves per plant of tomato due to different doses of cowdung at 30, 40, 50, 60 DAT and harvest (Figure 5 and Appendix XIX). Application of cowdung, C_2 treatment (10 ton/ha) produced the highest number of leaves 9.68, 23.07, 37.32, 48.63 and 64.86 at 30, 40, 50, 60 DAT and harvest, respectively. Separately, the lowest number of leaves of tomato were recorded from the C_0 treatment and suggesting that higher doses of cowdung increased the number of leaves of tomato. These results were agreed with the findings of Togun *et al.* (2004).

Interaction effect of chemical fertilizer and cowdung varied significantly for number of leaves per tomato plant at 30, 40, 50, 60 DAT and harvest (Table 2). The highest number of leaves per plant was recorded from F_1C_2 treatment at 30, 40 DAT but at 50,60 and harvesting stage F_2C_1 treatment showed the best performance and the lowest number of leaves from F_0C_0 treatments. There was a similar agreement with Singh *et al.* (2005), who found that application of 500:300:350 kg NPK/ha and decomposed cowdung increased the number of leaves of tomato plant. So, it is suggested that combined effects of chemical fertilizer and cowdung increased the

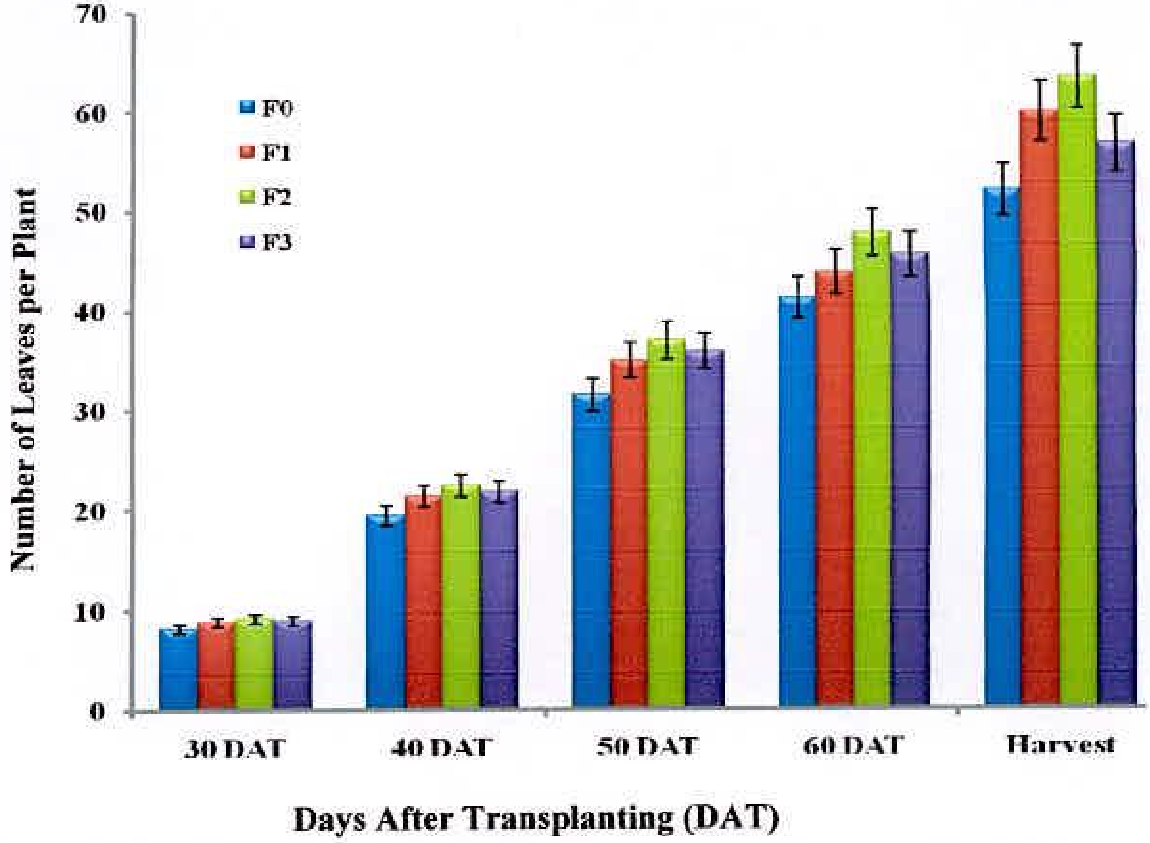


Figure 4. Effect of chemical fertilizers on number of leaves of tomato plant

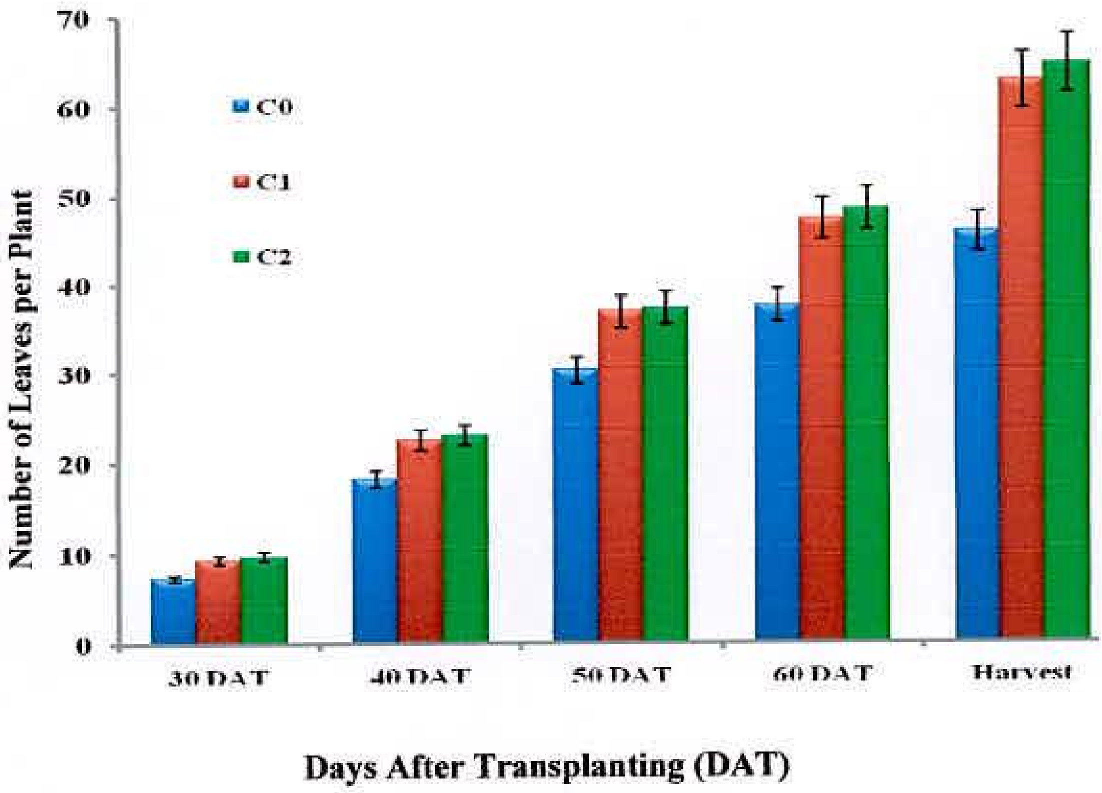


Figure 5. Effect of cowdung on number of leaves of tomato plant

Table 2. Interaction effect of chemical fertilizers and cowdung on number of leaves per plant of tomato

Treatments (F×C)	Number of leaves per plant at				
	30 DAT	40 DAT	50 DAT	60 DAT	Harvest
F_0C_0	6.07 g	20.80 bc	24.53 d	44.77 cd	40.35 f
F_0C_1	9.47 abcd	22.63 ab	36.43 ab	31.80 g	64.20 c
F_0C_2	8.93 cd	15.00 d	33.60 bc	47.10 bc	51.33 d
F_1C_0	7.33 f	19.10 c	31.47 c	37.87 f	48.87 de
F_1C_1	8.73 de	20.60 bc	33.90 bc	44.43 cd	53.20 d
F_1C_2	10.27 a	24.60 a	39.23 a	49.27 b	72.87 ab
F_2C_0	7.50 f	19.63 c	32.53 c	39.27 ef	52.19 d
F_2C_1	9.63 abc	24.17 a	39.67 a	54.03 a	77.53 a
F_2C_2	9.67 abc	23.57 a	39.17 a	49.70 b	64.87 c
F_3C_0	8.10 ef	19.40 c	32.70 c	41.43 de	42.53 ef
F_3C_1	9.33 bcd	22.67 ab	38.07 a	46.70 bc	61.53 c
F_3C_2	9.87 ab	23.33 a	36.87 ab	48.47 b	65.70 bc
$LSD_{(0.05)}$	**0.745**	**2.265**	**3.329**	**3.317**	**7.567**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV (%)	**5.03**	**6.28**	**5.64**	**8.40**	**7.71**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.1.3 Number of branches per plant

It has been suggested that the judicial application of NPK promotes branches of tomato (Bharkad *et al.* 2005 and Singh, 2005).The effect of different doses of chemical fertilizers for number of branches per plant of tomato was statistically significant at 30, 40, 50, 60 DAT and harvest (Figure 6 and Appendix XX). At 30, 40, 50, 60 DAT and harvest, the maximum number of branches per plant were recorded in the F_2 (3.39, 4.71, 6.24, 8.77 and 13.99) treatment and the minimum number of branches per plant of tomato were observed in the F_0 treatment (2.62, 3.58, 5.27, 7.33 and 11.84). Raut *et al.* (2003) observed that recommended doses of NPK had the maximum number of branches per plant of tomato.

It is suggested that cowdung positively increases the number of branches of tomato plant. There was a significant variation of number of branches per plant of tomato due to application of different amount of cowdung at 30, 40, 50, 60 DAT and harvest (Figure 7 and Appendix XX). The maximum number of branches per plant was recorded from the C_2 (3.40, 4.75, 6.59, 9.55 and 14.57) treatment, which was statistically similar with the C_1 treatment. Besides, the minimum number was recorded from the C_0 (2.28, 3.28, 4.62, 6.25 and 10.69) treatment at 30, 40, 50, 60 DAT and harvest, respectively. Togun *et al.* (2004) reported that compost had significant effects on number of branches in tomato plant. Periasamy (2009) also reported the similar findings.

Due to the application of different combination of chemical fertilizers and cowdung , the number of branches per plant of tomato at 30, 40, 50, 60 DAT and harvest was varied significantly (Table 3). At final harvest, the highest number of branches was observed from the F_2C_2 (16.07) treatment and consequently, the minimum number was observed from the F_0C_0 (8.63) treatment. Kumaran *et al.*(1998) reported that combined application of organic and inorganic fertilizers positively modulated the number of branches per plant of tomato.

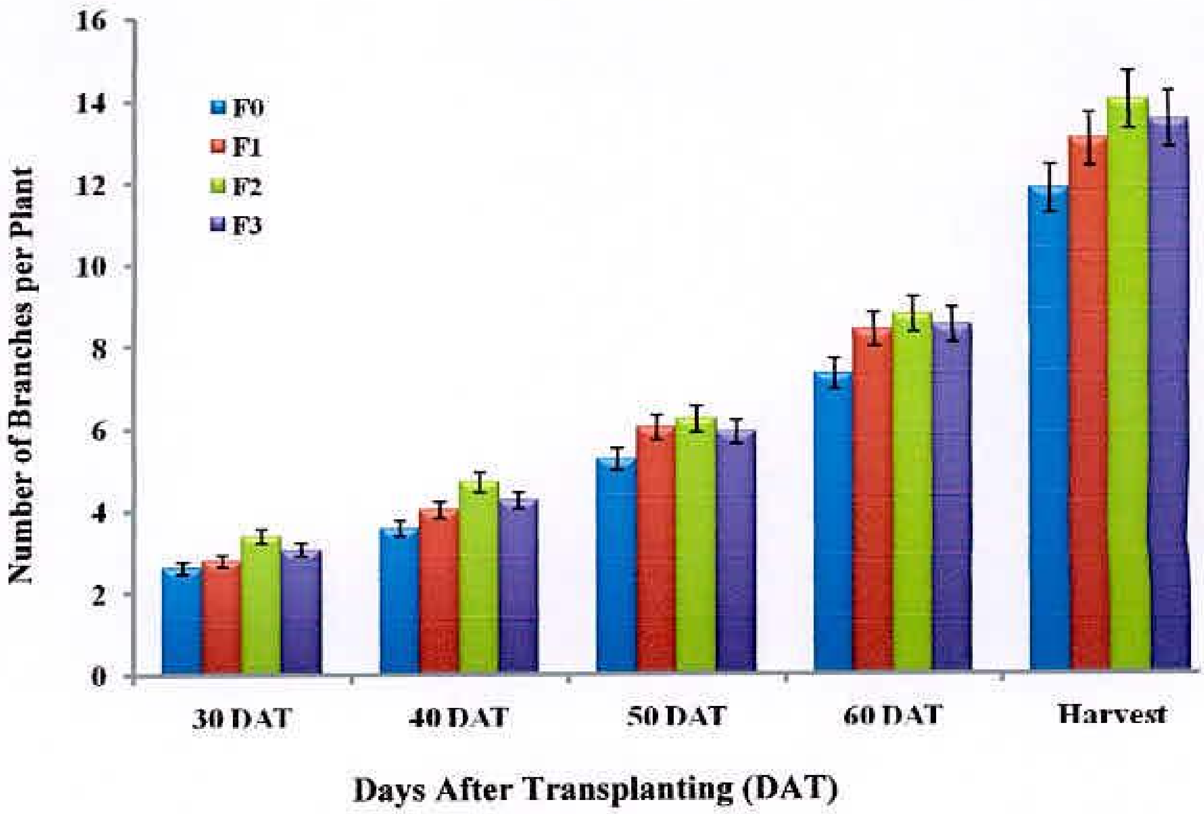


Figure 6. Effect of chemical fertilizers on number of branches of tomato plant

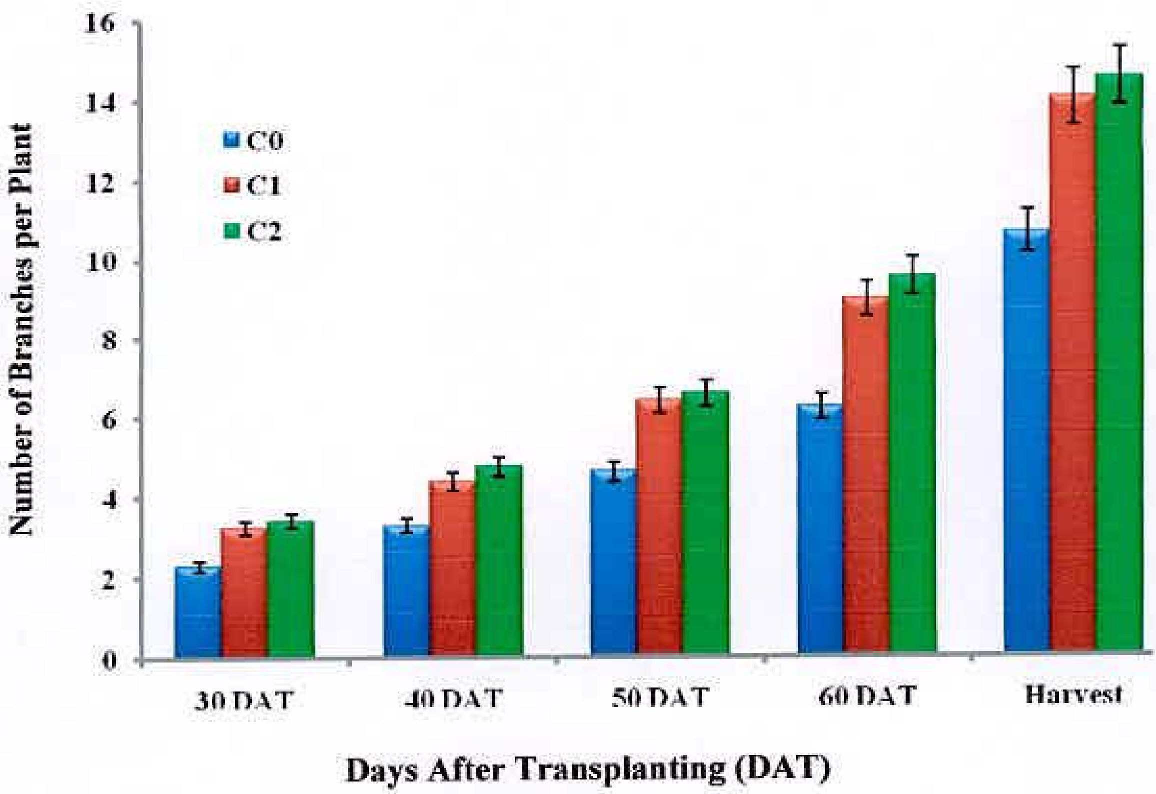


Figure 7. Effect of cowdung on number of branches of tomato plant

Table 3. Interaction effect of chemical fertilizers and cowdung on number of branches per plant of tomato

Treatments (F×C)	Number of branches per plant at				
	30 DAT	40 DAT	50 DAT	60 DAT	Harvest
F_0C_0	2.00 e	2.77 g	3.93 f	5.07 g	8.63 e
F_0C_1	3.23 c	4.17 cde	6.07 bc	8.63 bcd	14.07 b
F_0C_2	2.63 d	3.80 def	5.80 cd	8.30 cd	12.83 c
F_1C_0	2.07 de	3.23 fg	4.47 ef	5.95 fg	10.83 d
F_1C_1	2.37 de	3.40 efg	6.13 bc	8.33 cd	12.23 c
F_1C_2	4.00 a	5.43 a	6.80 ab	10.07 ab	15.23 ab
F_2C_0	2.60 d	3.57 efg	5.10 de	6.53 ef	11.73 cd
F_2C_1	4.00 a	5.30 ab	7.50 a	10.93 a	15.00 ab
F_2C_2	3.57 abc	5.27 ab	6.83 ab	9.70 abc	16.07 a
F_3C_0	2.43 de	3.57 efg	4.97 e	7.43 de	11.57 cd
F_3C_1	3.30 c	4.70 abc	6.60 bc	8.87 bcd	14.87 ab
F_3C_2	3.43 bc	4.50 bcd	6.23 bc	9.27 bc	14.13 b
$LSD_{(0.05)}$	**0.519**	**0.740**	**0.783**	**1.368**	**1.229**
Significance level	**0.01**	**0.01**	**0.05**	**0.01**	**0.01**
CV (%)	**10.36**	**10.55**	**7.88**	**9.78**	**5.54**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.1.4 Days required to 1st flowering from transplanting

It was suggested that increasing rate of chemical fertilizers prolonged the 1st flowering of tomato plant (Anant *et al.*, 2007 and Nanadal *et al.*, 1998). Application of different doses of chemical fertilizers had significant effects on days required to 1st flowering of tomato (Figure 8 and Appendix XXI). The minimum days required for 1st flowering in F_2 (42.71 days) treatment, whereas maximum days required in the treatment F_3 (47.78 days), which was statistically identical with the treatment F_0 (46.64 days).

Statistically significant variation was recorded for days to 1st flowering of tomato due to different levels of cowdung (Figure 9 and Appendix XXI). The minimum days from transplanting to 1st flowering was observed from the C_2 (45.10 days) treatment, which was statistically similar with the treatment C_1 (45.17 days) .The researcher reported that highest amount of cowdung in tomato encourages the early flowering of tomato.

Figure 10 and Appendix XXI showed that the interaction effect of chemical fertilizers and cowdung varied significantly in terms of days to 1st flowering of tomato plant. The minimum days from transplanting to 1st flowering were recorded from the F_2C_2 (40.80 days) treatment and the maximum days from transplanting to 1st flowering were observed from the treatment F_0C_0 (50.73 days). Present results also commensurated with the results observed by Khalil, 2001 and Shukla *et al.*, 2006.

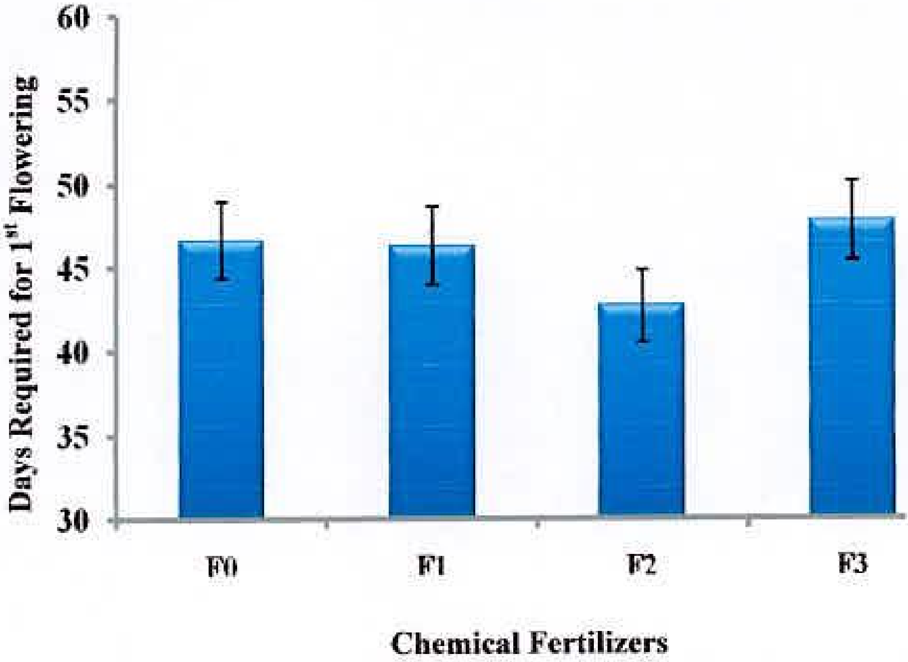


Figure 8. Effect of chemical fertilizers for days required to 1st flowering from transplanting of tomato plant

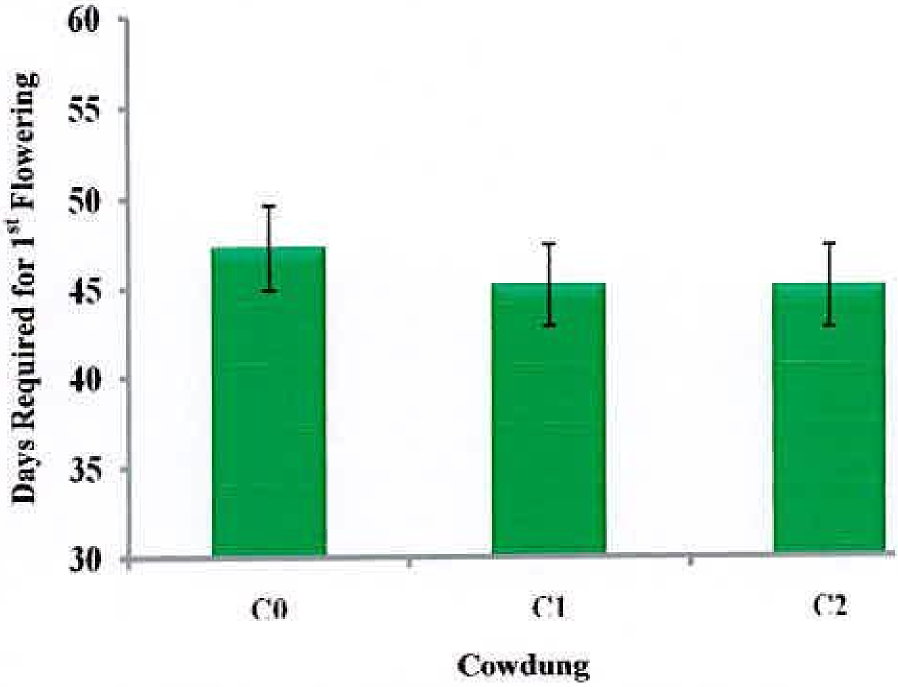


Figure 9. Effect of cowdung for days required to 1st flowering from transplanting of tomato plant

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

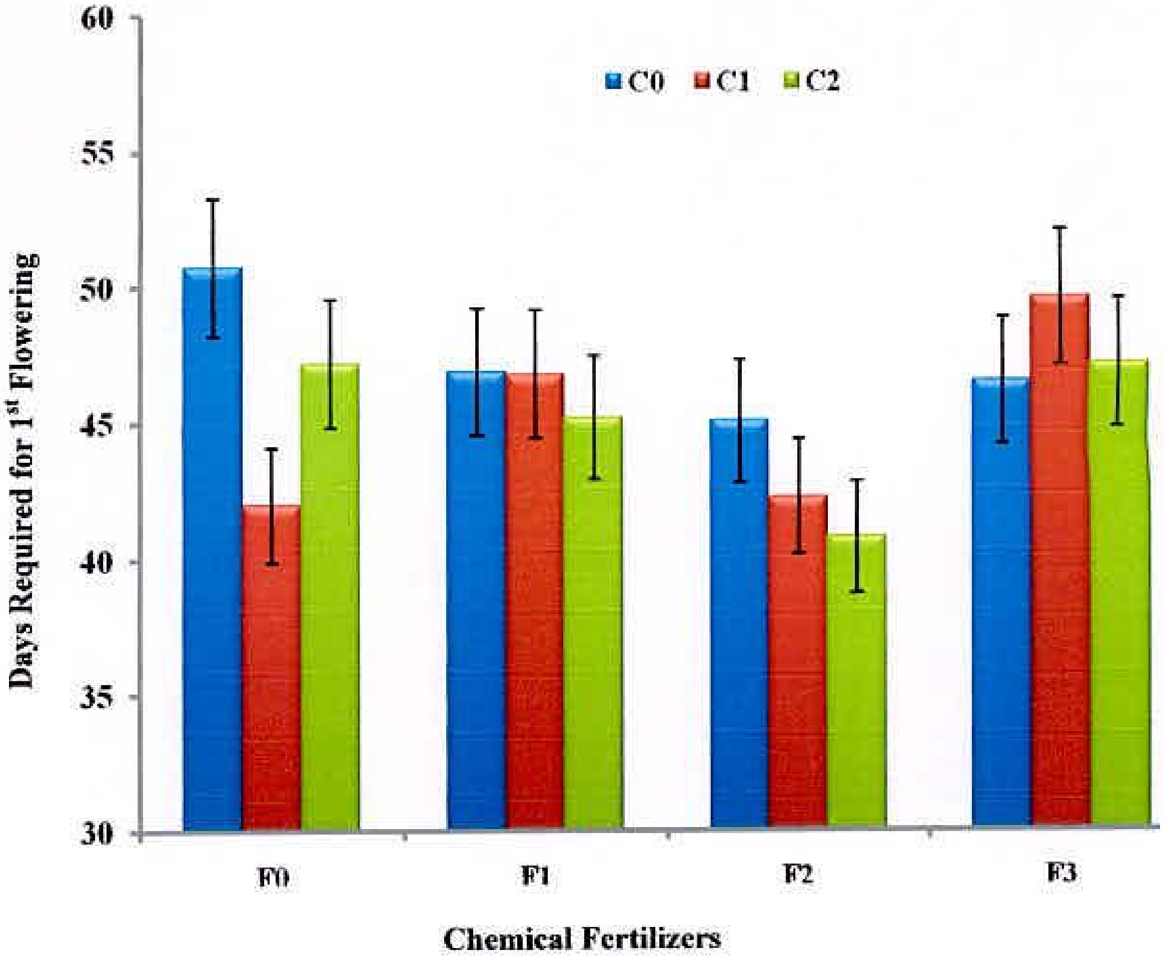


Figure 10. Interaction effects of chemical fertilizers and cowdung for days required to 1st flowering from transplanting of tomato plant

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.1.5 Dry matter content in plant

A number of research groups have been observed that chemical fertilizers influenced the dry matter content in tomato plant (Bineeth *et al.*, 2004, Colla *et al.*, 2003 and Montemurro *et al.*, 1999). Different doses of chemical fertilizers varied significantly for dry matter content in tomato plant at 40, 50 and 60 DAT (Table 4 and Appendix XXIII). The maximum dry matter content was found in the treatment F_3 (18.23%) which statistically similar with the treatment F_2 (17.94%) and F_1 (16.91%) at 60 DAT. Besides, the minimum dry matter content in plant of tomato was obtained from the treatment F_0 (15.25%) at the same DAT. These results have the similarity with Salam *et al.* (2009).

Significant variation was recorded for dry matter content in tomato plant due to different amount of cowdung at 40, 50 and 60 DAT (Table 4 and Appendix XXIII). Maximum dry matter content of plant was recorded from the treatment C_2 (11.95%, 14.57%, and 18.25%) which was statistically similar with the treatment C_1 (11.77%, 14.12%, and 17.15%), whereas the minimum data was recorded from the treatment C_0 (10.98%, 13.44%, and 15.85%) at 40,50 and 60 DAT. Sable *et al.* (2007) agreed the similar results with this study.

Table 5 and Appendix XXIII showed statistically significant variation in interaction effect of chemical fertilizers and cowdung in terms of dry matter content of tomato plant at 40, 50 and 60 DAT. At 60 DAT, maximum dry matter content in tomato plant was found from the treatment F_3C_1 (19.31%) which was statistically similar with F_3C_2 (19.11). On the other hand, the minimum dry matter content in tomato plant was also found from the treatment F_0C_0 (9.08%, 11.54%, and 12.42%) from all the different DAT. Shukla *et al.* (2006) observed that NPK with organic matter induced total dry mass of tomato plant.

Table 4. Effect of chemical fertilizers and cowdung on dry matter content of tomato plant

Treatments	Dry matter content in plant (%) at		
	40 DAT	50 DAT	60 DAT
Chemical fertilizer			
F_0	10.04 c	12.54 c	15.25 b
F_1	11.60 b	13.80 b	16.91 a
F_2	12.58 a	15.42 a	17.94 a
F_3	12.06 ab	14.41 b	18.23 a
$LSD_{(0.05)}$	**0.606**	**0.885**	**1.444**
Significance level	**0.01**	**0.01**	**0.01**
Cowdung			
C_0	10.98 b	13.44 b	15.85 b
C_1	11.77 a	14.12 ab	17.15 a
C_2	11.95 a	14.57 a	18.25 a
$LSD_{(0.05)}$	**0.525**	**0.766**	**1.250**
Significance level	**0.01**	**0.01**	**0.01**
CV (%)	**5.36**	**6.45**	**8.64**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

Table 5. Interaction effect of chemical fertilizers and cowdung on dry matter content of tomato plant

Treatments (F×C)	Dry matter content in plant (%) at		
	40 DAT	50 DAT	60 DAT
F_0C_0	9.08 f	11.54 f	12.42 d
F_0C_1	10.48 e	12.7 ef	16.06 bc
F_0C_2	10.55 e	13.30 cde	17.27 abc
F_1C_0	11.01 de	13.24 de	15.61 c
F_1C_1	11.86 bcd	13.94 cde	17.22 abc
F_1C_2	11.94 bcd	14.22bcde	17.90 abc
F_2C_0	11.62 cde	14.36bcde	16.65 abc
F_2C_1	11.52 cde	16.15 a	16.00 bc
F_2C_2	12.91 ab	15.7 ab	18.73 ab
F_3C_0	12.23 abc	14.6 abcd	18.72 ab
F_3C_1	13.21 a	13.62 cde	19.31 a
F_3C_2	12.42 abc	15.00 abc	19.11 a
$LSD_{(0.05)}$	**1.051**	**1.533**	**2.501**
Significance level	**0.05**	**0.05**	**0.05**
CV (%)	**5.36**	**6.45**	**8.64**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.2 Yield contributing characteristics

4.2.1 Viable pollen

It has been found that increased levels of chemical fertilizers also increased the percentage of viable pollen in tomato plant (Qin and Li 2007). There had a significant variation for viable pollen of tomato for the application of different levels of chemical fertilizers (Table 6 and Appendix XXIV). The highest number of viable pollen were recorded from the treatment F_2 (64.5%) which was statistically similar with the treatment F_1 (63.50%) and the lowest number of viable pollen were found from the treatment F_0 (52.83%). Turemis and Darin, (2000) reported the similar findings with this investigation.

Table 6 and Appendix XXIV showed *statistically significant variation in terms of viable* pollen of tomato due to application of different levels of cowdung. The largest amount of viable pollen were observed from the treatment C_1 (63.63%) which was closely followed by the treatment C_2 (58.00%), whereas the lowest number of viable pollen were recorded from the treatment C_0 (54.88%). The findings of this investigation were agreed with Sable *et al.* (2007).

The combined effect of chemical fertilizers and cowdung showed significant differences in favor of viable pollen of tomato (Table 7). The highest number of viable pollen was recorded from the treatment F_2C_2 (70.00%) (Appendix XVII), which was statistically similar with the treatment F_3C_1 (70.00%) (Appendix XVII) and the lowest number viable pollen was found from the treatment F_3C_0 (44.50%) which was statistically similar with the treatments F_3C_2 (59.00%) and F_0C_2 (47.50%), respectively. Sable *et al.* (2007) found the similar findings with this study.

4.2.2 Non-viable pollen

Biological scientists from different countries have already been investigated that inorganic fertilizers increased the number of viable pollens in tomato plant (Turemis and Darin, 2000 and Qin and Li, 2007). Non-viable pollen of tomato varied significantly due to the application of different levels of chemical fertilizers (Table 6 and Appendix XXIV). The lowest number of non-viable pollen of tomato was recorded from the treatment F_2 (35.50%) which was statistically similar with the treatment F_1 (36.50%), whereas, the highest number of non-viable pollen of tomato was observed from the treatment F_0 (47.17%) which was statistically identical with the treatment F_3 (45.50%). Researcher of this investigation also reported the similar findings with the scientists.

It was observed that different levels of cowdung varied significantly for non-viable pollen of tomato (Table 6 and Appendix XXIV). The lowest number of non-viable pollen was observed from the treatment C_1 (36.38%) and the highest number of non-viable pollen was found from the treatment C_0 (45.13%). Sable *et al.* (2007) reported that the recommended fertilizer rates (100:50:50 kg N, K_2O, P_2O_5/ha) and the organic manures were generally superior to the enhancement of the pollen viability (%) of tomato plant.

The variation of non-viable pollen of tomato found statistically significant due to interaction effect of chemical fertilizers and cowdung (Table 7). The lowest number of non-viable pollen was obtained from the treatments F_3C_1 and F_2C_2 (30.00%) which was statistically identical with the treatments F_1C_1 (33.00%) and F_1C_2 (34.50%) (Appendix XVI). Besides, the highest number of non-viable pollen was recorded from the treatment F_3C_0 (55.50%). Sable *et al.* (2007) found the similar findings with this study.

4.2.3 Number of flower cluster per plant

Application of different levels of chemical fertilizers varied significantly in the number of flower cluster per plant of tomato (Table 6 and Appendix XXI). The maximum number of flower cluster per plant was found from the treatment F_2 (9.98) which was statistically identical with the treatments F_1 and F_3 (9.77), whereas, the minimum number was observed from the treatment F_0 (8.87). The similar observation was reported by Singh *et al.* (2005), who found that the effects of NPK recorded the highest number of flower clusters per plant.

The results in Table 6 and Appendix XXI revealed that the effect of cowdung varied significantly in terms of number of flower cluster per plant of tomato. The maximum number of flower cluster per plant was obtained from the treatment C_1 (10.79) which were statistically identical with the treatment C_2 (10.35) and the minimum number was observed from the treatment C_0 (7.64). Krishna and Krishnappa (2002) reported that the effect of NPK fertilizer applied with or without organic manures recorded flower clusters per plant of tomato.

Table 7 and Appendix XXI reported that combined effect of chemical fertilizers and cowdung showed significant variation in number of flower cluster per plant The largest number of flower cluster per plant was recorded from the treatment F_1C_2 (11.70) and that was statistically identical with the treatments F_2C_2 (11.03), F_3C_2 (11.07). Consequently, the lowest number of number of flower cluster per plant of tomato was recorded from the treatment F_0C_0 (6.90) which was statistically identical with the treatments F_1C_0 (7.80), F_2C_0 (7.80) and F_3C_0 (8.07), respectively. Solaiman and Rabbani (2006) also observed the same findings with the abovementioned results.

4.2.4 Number of flowers per cluster

Number of flowers per cluster of tomato was found in increased trend with the application of chemical fertilizers by the researchers from many countries (Bharkad *et al.*, 2005 and Nanadal *et al.*, 1998). Chemical fertilizers had significant effects on the number of flowers per cluster of tomato (Table 6 and Appendix XXI). The maximum number of flowers per cluster was recorded from the treatment F_2 (6.27) which were statistically identical with the treatment F_3 (5.83). On the other hand, the minimum number was found from the treatment F_0 (5.02) in regard to number of flowers per cluster. Singh *et al.* (2005) found that the effects of NPK recorded the highest number of flower clusters per with the application of 500:300:350 kg NPK/ha in tomato plant.

Due to the effects different levels of cowdung on the number of flowers per cluster of tomato varied significantly (Table 6 and Appendix XXI). The highest number of flowers per cluster was found from the treatment C_1 (6.43) which were statistically identical with the treatment C_2 (6.22), while the lowest number of flowers per cluster of tomato was observed from the treatment C_0 (4.27). The findings of this study were agreed with Nanadal *et al.* (1998). So, it was suggested that different rates of cowdung influenced the number of flowers per cluster of tomato.

Significant variation was observed for interaction effect of chemical fertilizers and cowdung in terms of number of flowers per cluster of tomato (Table 7 and Appendix XXI). The largest number of flowers per cluster was found from the treatment F_2C_1 (7.17) which was statistically identical with the treatments F_1C_2 (6.80) and F_2C_2 (7.13), F_3C_1 (6.53), F_3C_2 (6.77) and F_0C_1 (6.63), respectively. Next to it, the minimum number was recorded from the treatment F_1C_0 (3.80) which was statistically identical with the treatments F_0C_2 (4.63), F_0C_0 (4.20) and F_3C_0 (4.20), respectively. Krishna and Krishnappa (2002), Itoo and Manivannan (2004), Naidu *et al.* (2001) and Raut *et al.* (2003) also supported the findings of the abovementioned results.

Table 6. Effect of chemical fertilizers and cowdung on pollen viability (%), number of flower cluster per plant, number of flowers per cluster, number of flowers per plant, number of fruits per cluster and days from transplanting to 1st harvesting of tomato

Treatments	Pollen viability (%)		Number of flower cluster per plant	Number of flowers per cluster	Number of flowers per plant	Number of fruits per cluster	Days from transplanting to 1st harvesting
	Viable	Non-Viable					
Chemical fertilizers							
F_0	52.83 b	47.17 a	8.87 b	5.02 c	45.45 c	4.89 c	82.87 bc
F_1	63.50 a	36.50 b	9.77 a	5.42 bc	53.06 b	5.11 b	84.22 ab
F_2	64.50 a	35.50 b	9.98 a	6.27 a	61.98 a	6.43 a	81.64 c
F_3	54.50 b	45.59 a	9.77 a	5.83 ab	56.83 b	5.70 b	85.19 a
$LSD_{(0.05)}$	**3.332**	**3.332**	**0.650**	**0.543**	**4.608**	**0.301**	**2.012**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Cowdung							
C_0	54.88 c	45.13 a	7.64 b	4.27 b	32.68 b	5.16 b	83.38 b
C_1	63.63 a	36.38 c	10.79 a	6.43 a	64.56 a	5.80 a	81.61 c
C_2	58.00 b	42.00 b	10.35 a	6.22 a	65.76 a	5.94 a	85.45 a
$LSD_{(0.05)}$	**2.886**	**2.886**	**0.563**	**0.470**	**3.991**	**0.261**	**1.743**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV (%)	**5.79**	**8.28**	**6.94**	**9.86**	**8.68**	**5.48**	**7.47**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

Table 7. Interaction effect of chemical fertilizers and cowdung on pollen viability (%), number of flower cluster per plant, number of flowers per cluster, number of flowers per plant, number of fruits per cluster and days from transplanting to 1st harvesting of tomato

Treatments (F×C)	Pollen viability (%)		Number of flower cluster per plant	Number of flowers per cluster	Number of flowers per plant	Number of fruits per cluster	Days from transplanting to 1st harvesting
	Viable	Non-Viable					
F_0C_0	56.00 d	44.00 b	6.90 d	4.20 bc	26.54 g	4.43 d	82.23 cde
F_0C_1	55.00 d	45.00 b	10.33 bc	6.63 a	68.31 bc	5.63 c	82.77 cde
F_0C_2	47.50 e	52.50 a	9.37 c	4.63 bc	41.51 de	4.40 d	83.60 bcd
F_1C_0	58.00 cd	42.00 bc	7.80 d	3.80 c	32.84 fg	5.60 c	86.90 ab
F_1C_1	67.00 ab	33.00 de	9.80 c	4.90 b	48.04 d	4.60 d	80.03 de
F_1C_2	65.50 ab	34.50 de	11.70 a	6.80 a	78.30 a	6.33 ab	85.73 abc
F_2C_0	61.00 bcd	39.00 bcd	7.80 d	4.87 b	37.41 ef	5.70 c	85.13 abc
F_2C_1	62.50 bc	37.50 cd	11.10 ab	7.17 a	75.50 ab	6.83 a	76.30 f
F_2C_2	70.00 a	30.00 e	11.03 ab	7.13 a	73.03 abc	6.77 a	83.50 bcd
F_3C_0	44.50 e	55.50 a	8.07 d	4.20 bc	33.91 efg	4.90 d	79.27 ef
F_3C_1	70.00 a	30.00 e	10.17 bc	6.53 a	66.40 c	6.13 bc	87.33 ab
F_3C_2	59.00 e	51.00 a	11.07 ab	6.77 a	70.19 abc	6.07 bc	88.97 a
$LSD_{(0.05)}$	**5.772**	**5.772**	**1.127**	**0.941**	**7.981**	**0.522**	**3.485**
Significance level	**0.01**	**0.01**	**0.05**	**0.01**	**0.01**	**0.01**	**0.01**
CV (%)	**5.79**	**8.28**	**6.94**	**9.86**	**8.68**	**5.48**	**7.47**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.2.5 Number of flowers per plant

It was found that different chemical fertilizers increased the number of flowers per plant of tomato (Bharkad *et al.*, 2005 and Singh *et al.*, 2005). Number of flowers per plant of tomato varied significantly due to application of different levels of chemical fertilizers (Table 6 and Appendix XXI). The maximum number of flowers per plant was recorded from the treatment F_2 (61.98) which was closely followed by the treatments F_3 (56.83) and F_1 (53.06), and consequently, the minimum number was observed from the treatment F_0 (45.45). Nanadal *et al.* (1998), Podsiado and Karczmarczyk (2001) positively agreed with these results.

Statistically significant variation was recorded in terms of number of flowers per plant of tomato due to different levels of cowdung (Table 6 and Appendix XXI). The maximum number of flowers per plant was recorded from the treatment C_2 (65.76) which were statistically identical with the treatment C_1 (64.56), while the minimum number was found from the treatment C_0 (32.68). Togun *et al.* (2003) reported with the similar findings of this investigation. It is reported by the researcher that different compositions of cowdung had the positive results in terms of number of flowers per plant of tomato.

Interaction effect of chemical fertilizers and cowdung showed significant variation in number of flowers per plant of tomato (Table 7 and Appendix XXI). The maximum number of flowers per plant was recorded from the treatment F_1C_2 (78.30) which was statistically closely related to the treatments F_2C_1 (75.50), F_2C_2 (73.03) and F_3C_2 (70.19), respectively. On the other hand, the lowest number of flowers per plant of tomato was recorded from the treatment F_0C_0 (26.54) and closely related to the treatments F_1C_0 (32.84) and F_3C_0 (33.91), respectively. There were similar results with this study found by Togun *et al.* (2003), Solaiman and Rabbani (2006).

4.2.6 Number of fruits per cluster

Number of fruits per cluster of tomato varied significantly for the application of different combinations of chemical fertilizers (Table 6 and Appendix XXI). The maximum number of fruits per cluster was found from the treatment F_2 (6.43) which was closely followed by the treatments F_3 (5.70) and F_1 (5.51), whereas, the lowest number was recorded from the treatment F_0 (4.89). The similar results were found by Nanadal *et al.*

(1998), who found that increasing levels of P and K improved number of fruits per cluster of tomato.

Table 6 and Appendix XXI results reported that number of fruits per cluster of tomato varied significantly for different levels of cowdung. The highest number of fruits per cluster was recorded from the treatment C_2 (5.94) which were statistically identical with the treatment C_1 (5.80), again the lowest number of fruits per cluster was observed from the treatment C_0 (5.16).

Remarkable variation was observed in respect of number of fruits per cluster of tomato among the interaction effect of chemical fertilizers and cowdung (Table 7 and Appendix XXI). The largest number of fruits per cluster was recorded from the treatment F_2C_1 (6.83) (Appendix XI), which was statistically similar with the treatment F_2C_2 (6.77) (Appendix X). Besides, the minimum number was found from the treatment F_0C_0 (4.43) and statistically similar with the treatments F_0C_2 (4.40), F_1C_1 (4.60), and F_3C_0 (6.13), respectively (Appendix XII). Krishna and Krishnappa (2002) reported that the effect of NPK fertilizer applied with or without organic manures recorded the highest values fruits per cluster of tomato.

4.2.7 Days required to 1st harvesting from transplanting

Days required to 1st harvesting from transplanting of tomato varied significantly due to the application of different levels of chemical fertilizers (Table 6 and Appendix XXI). The minimum days required to 1st harvesting were recorded in the treatment F_2 (81.64 days) which was statistically identical with the treatment F_0 (82.87 days), whereas the maximum days were observed from the treatment F_3 (85.19 days) which was statistically identical with the treatment F_1 (84.22 days). The findings of this study were found agreed with Nanadal *et al.* (1998) and Ashok *et al.* (2003).

Table 6 and Appendix XXI showed that there was a significant variation in terms of days required to 1st harvesting of tomato from transplanting due to application of different composition of cowdung. The minimum days from transplanting to 1st harvesting were observed in the treatment C_1 (81.61 days) which was closely followed by the treatment C_0 (83.38 days) and the maximum days were found in the treatment C_2 (85.45 days).

There was a significant increasing pattern observed due to interaction effect of chemical fertilizer and cowdung for days from transplanting to 1st harvesting of tomato (Table 7 and Appendix XXI). The minimum days from transplanting to 1st harvesting was recorded from the treatment F_2C_1 (76.30 days) which was statistically identical with the treatment F_3C_0 (79.27), while the maximum days were recorded from the treatment F_3C_2 (88.97 days). Anant *et al.* (2007) observed the increasing data for days taken to first flowering using inorganic fertilizers with organic fertilizers.

4.2.8 Number of fruits per plant

Application of different levels of chemical fertilizers in respect of number of fruits per plant of tomato varied significantly (Table 8 and Appendix XXII). The highest number of fruits per plant was recorded from the treatment F_2 (43.63) which was closely followed by the treatments F_3 (35.81) and F_1 (33.63), whereas the lowest number of fruits per plant was observed from the treatment F_0 (25.74). Krishna and Krishnappa (2002) observed that the effect of NPK fertilizer recorded the highest values for fruits per plant of tomato. It is found that effects of chemical fertilizers influence the number of fruits per plant of tomato plant.

The effect of the treatments of cowdung found statistically significant for number of fruits per plant of tomato (Table 8 and Appendix XXII). The highest number of fruits per plant was observed from the treatment C_2 (40.19) which were statistically identical with the treatment C_1 (39.71) and the lowest number was observed from the treatment C_0 (24.20). Togun *et al.* (2003) reported similar findings with this investigation.

There was a significant difference among the combined effect of chemical fertilizers and cowdung for number of fruits per plant (Table 9 and Appendix XXII). The largest number of fruits per plant was recorded from the treatment F_2C_1 (53.70) which were statistically identical with the treatment F_2C_2 (48.55). On the other hand, the lowest number of fruits per plant was observed from the treatment F_0C_0 (16.70). Solaiman and Rabbani (2006) found the same observation with this study. Itoo and Manivannan, 2004, Jan, *et al.* (2006) and Singh *et al.* (2005) found similarity with these results.

4.2.9 Fruit length

Application of different levels of chemical fertilizers varied significantly for length of tomato fruit (Table 8 and Appendix XXII). The highest length of fruit was obtained from the treatment F_2 (5.19 cm) which was statistically similar with the treatments F_1 (5.10 cm) and F_3 (4.87 cm), and the lowest length of tomato fruit was recorded from the treatment F_0 (4.02 cm). These results were similar with Chaurasia *et al.* (2006) and Hamsaveni *et al.* (2003), found that gypsum application resulted in largest fruits per plant of tomato.

Length of fruit varied significantly due to the application of different doses of cowdung (Table 8 and Appendix XXII). The highest length of fruit was recorded from the treatment C_2 (5.32 cm), which were statistically identical with the treatment C_1 (5.06 cm), whereas the lowest fruit length was found from the treatment C_0 (4.00 cm). It was observed that increasing rate of cowdung increased the length of fruit of tomato. Qingren *et al.* (2008) reported the similar findings with this works.

Table 9 and Appendix XXII showed the statistically significant variation in terms of fruit length of tomato due to the effect of chemical fertilizers along with cowdung. The highest length of fruit was obtained from the treatment F_2C_1 (6.18 cm) (Appendix XIII) which was statistically identical with the treatments F_1C_2 (5.77), F_2C_2 (5.51) and F_3C_2 (5.36) and the lowest length of fruit of tomato was recorded from the treatment F_0C_0 (3.50 cm) and which was statistically identical with the treatments F_0C_1 (4.31), F_1C_0 (4.08) and F_3C_0 (4.11). Solaiman and Rabbani (2006) and Yoldas *et al.* (2009) reported that organic and inorganic fertilizer increased fruit diameter and length of tomato.

4.2.10 Fruit diameter

A significant increase in diameter of fruit of tomato was recorded due to the application of different levels of chemical fertilizers (Table 8 and Appendix XXII). The highest diameter of fruit was found from the treatment F_3 (4.71 cm) which was closely followed by the treatments F_2 (4.40 cm) and F_1 (4.13 cm), while the lowest diameter was found from the treatment F_0 (3.68 cm). These results were similar with Chaurasia *et al.* (2006) and Hamsaveni *et al.* (2003). Sharma *et al.* (2001), Singh (2005) and Yagmur *et al.* (2004) also agreed with the aforementioned observations.

There was a significant variation in Table 8 and Appendix XXII for the diameter of fruit of tomato in respect of different treatments of cowdung. The highest diameter of fruit was obtained from the treatment C_1 (4.50 cm) which was statistically identical with the treatment C_2 (4.47 cm), whereas the lowest diameter of fruit of tomato was observed from the treatment C_0 (3.72 cm). The similar observation was found by Qingren *et al.* (2008) with this study.

Table 9 and Appendix XXII showed significant variation for diameter of tomato fruit in regard to interaction effect of chemical fertilizers and cowdung. The highest diameter of tomato fruit was found from the treatments F_2C_1 (5.08 cm) (Appendix XIII) and F_2C_2 (5.08) which was statistically similar with the treatments F_3C_1 (4.85) and F_1C_2 (4.93). Consequently, the lowest diameter of tomato fruit was recorded from the treatment F_0C_0 (3.37 cm) and statistically identical with the treatments F_0C_2 (3.50), F_3C_0 (3.82), respectively. Solaiman and Rabbani (2006) and Yoldaş *et al.* (2009) reported that organic and inorganic fertilizers increased fruit diameter and length of tomato.

4.2.11 Weight of individual fruit

The weight of individual fruit of tomato (Table 8 and Appendix XXII) differed significantly due to the application of different amount chemical fertilizers. The highest weight of individual fruit of tomato was obtained from the treatment F_2 (86.47 g), which was statistically identical with the treatments F_1 (84.72 g) and F_3 (83.76 g). On the other hand, the lowest weight was recorded from the treatment F_0 (75.99 g). The result was agreed with the findings of Chandra *et al.* (2003).

There also had a statistically significant variation recorded in terms of weight of individual fruit of tomato due to different doses of cowdung (Table 8 and Appendix XXII). The highest weight of individual fruit of tomato was found from the treatment C_2 (87.72 g), which was statistically identical with the treatment C_1 (86.28 g), and the lowest weight of individual fruit of tomato was observed from the treatment C_0 (74.22 g). The similar observations were found by Qingren *et al.* (2008).

The different combined treatments of chemical fertilizers and cowdung varied significantly in respect of weight of individual fruit (Table 9 and Appendix XXII). From these integrated treatments, the highest weight of individual fruit was recorded from the treatments F_2C_2 and F_3C_2 (92.43 g) and statistically similar with the treatment F_1C_2

(91.06 g) and the lowest weight of individual fruit was observed from the treatment F_0C_0 (64.13 g). Itoo and Manivannan (2004) and Yoldaş *et al.* (2009) observed that organic and inorganic fertilizer significantly increased fruit diameter and length, and average weight of tomato.

Table 8. Effect of chemical fertilizers and cowdung on number of fruits per plant, fruit length (cm), fruit diameter (cm), weight of individual fruit (g), yield (ton/ha) of tomato

Treatments	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Weight of Individual fruit (g)	Yield (ton/ha)
Chemical fertilizer					
F_0	25.74 c	4.02 b	3.68 c	75.99 b	48.64 b
F_1	33.63 b	5.10 a	4.13 b	84.72 a	59.09 a
F_2	43.63 a	5.19 a	4.40 b	83.76 a	61.16 a
F_3	35.81 b	4.87 a	4.71 a	86.47 a	59.56 a
$LSD_{(0.05)}$	**3.053**	**0.548**	**0.290**	**5.024**	**2.493**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Cowdung					
C_0	24.20 b	4.00 b	3.72 b	74.22 b	45.88 b
C_1	39.71 a	5.06 a	4.50 a	86.28 a	62.43 a
C_2	40.19 a	5.32 a	4.47 a	87.72 a	63.02 a
$LSD_{(0.05)}$	**2.644**	**0.475**	**0.251**	**4.351**	**2.159**
Significance level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV (%)	**9.00**	**11.72**	**7.01**	**6.21**	**4.46**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

Table 9. Interaction effect of chemical fertilizers and cowdung on number of fruits per plant, fruit length (cm), fruit diameter (cm), weight of individual fruit (g), yield (ton/ha) of tomato

Treatments (F×C)	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Weight of Individual fruit (g)	Yield (ton/ha)
F_0C_0	16.70 f	3.50 d	3.37 e	64.13 d	28.47 g
F_0C_1	37.58 d	4.31 cd	4.17 bc	84.43 abc	59.40 d
F_0C_2	22.94 e	4.24 cd	3.50 de	79.42 bc	58.07 de
F_1C_0	28.05 e	4.08 cd	3.67 cde	77.41 c	49.93 f
F_1C_1	25.50 e	5.03 bc	3.79 cde	85.70 abc	60.60 cd
F_1C_2	47.33 bc	5.77 ab	4.93 a	91.06 a	66.73 ab
F_2C_0	28.64 e	4.30 cd	4.03 bcd	78.43 c	50.73 f
F_2C_1	53.70 a	6.18 a	5.08 a	88.56 ab	67.93 a
F_2C_2	48.55 ab	5.51 ab	5.08 a	92.43 a	64.80 abc
F_3C_0	23.40 e	4.11 cd	3.82 cde	76.90 c	54.40 ef
F_3C_1	42.07 cd	5.14 abc	4.85 a	82.57 abc	61.80 cd
F_3C_2	41.95 cd	5.36 ab	4.54 ab	92.43 a	62.47 bcd
$LSD_{(0.05)}$	**5.287**	**0.950**	**0.502**	**8.703**	**4.318**
Significance level	**0.01**	**0.01**	**0.01**	**0.05**	**0.01**
CV (%)	**9.00**	**11.72**	**7.01**	**6.21**	**4.46**

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

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

4.2.12 Yield per hectare

The effects of different doses of chemical fertilizers on yield of tomato per hectare found statistically significant (Table 8 and Appendix XXII). The highest yield of tomato was found from the treatment F_2 (61.16 t/ha) which was statistically identical with the treatments F_1 (59.56 t/ha) and F_3 (59.09 t/ha), whereas the lowest yield was recorded from the treatment F_0 (48.64 t/ha). These results were similar with Chandra *et al.* (2003). It is agreed with the aforementioned findings that tomato yield significantly increased in respect of different composition of chemical fertilizers application.

Table 8 and Appendix XXII showed statistically significant variations in terms of yield of tomato per hectare due to different doses of cowdung. The highest yield of tomato was obtained from the treatment C_2 (63.02 t/ha) which were statistically identical with the treatment C_1 (62.43 t/ha) and the lowest yield of tomato was recorded from the treatment C_0 (45.88 t/ha). The similar observation was found by Qingren *et al.* (2008), Krishna and Krishnappa (2002) observed the similar observation with this investigation.

The remarkable statistical variation was found from the interaction effect of chemical fertilizers and cowdung for yield of tomato per hectare (Table 9 and Appendix XXII). The highest yield of tomato per hectare was recorded from the treatment F_2C_1 (67.93 t/ha) which was statistically identical with the treatments F_1C_2 (66.73 t/ha) while the lowest was obtained from the treatment F_0C_0 (28.47 t/ha) where did not have any chemical fertilizers and manure. The similar results were found by Shukla *et al.* (2006), Jan *et al.* (2006), Singh *et al.* (2005) and Gupta and Sengar (2000).

4.3 Qualitative characteristics of tomato

4.3.1 Shelf life in open condition

The results (Figure 11 and appendix XXIV) reported in response of shelf life of tomato in open condition varied significantly due to the application of different levels of chemical fertilizers. The highest shelf life was recorded from the treatment F_1 (9.33 days) which was statistically similar with the treatment F_2 (9.22 days). On the other hand, the lowest was found from the treatment F_3 (8.33 days) which was statistically identical with the treatment F_0 (8.33 days). These results were similar with Chandra *et al.* (2003). It is suggested that the application of different levels of chemical fertilizers increased the variation of the shelf life of tomato fruit.

Shelf life of tomato in open condition varied significantly for different levels of cowdung (Figure 12 and appendix XXIV). The highest shelf life of tomato was obtained from the treatment C_2 (9.50 days) and C_1 (9.08 days) while the lowest was observed from the treatment C_0 (7.75 days). Zhai *et al.* (2009) observed that organic tomatoes had a lower post harvest decay index (better shelf life). It is suggested that organic manures influence the shelf life of tomato fruit.

The combined effect of chemical fertilizers and cowdung in terms of shelf life in open condition of tomato found statistically significant (Figure 13 and appendix XXIV). The highest shelf life of tomato was found from the treatment F_2C_1 (10.67 days) and statistically identical with the treatment F_1C_2 (10.33 days), consequently, the lowest shelf life of tomato was recorded from the treatment F_0C_0 (6.33 days) and also statistically identical with the treatment F_3C_1 (7.33 days). Krishna and Krishnappa (2002) found the similar findings with the investigation.

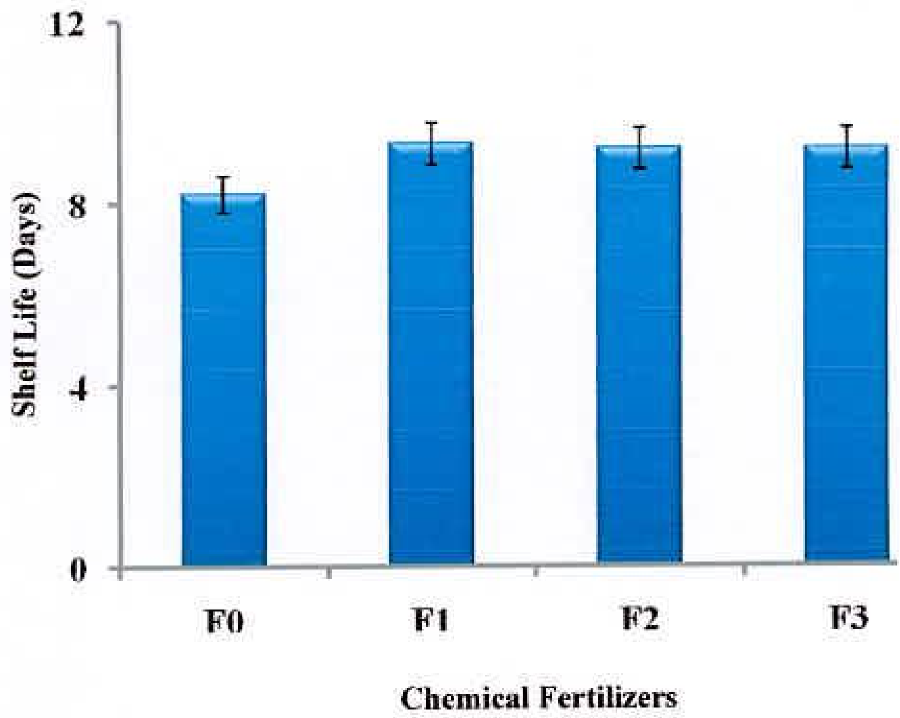


Figure 11. Effect of chemical fertilizers on shelf life of tomato in open condition

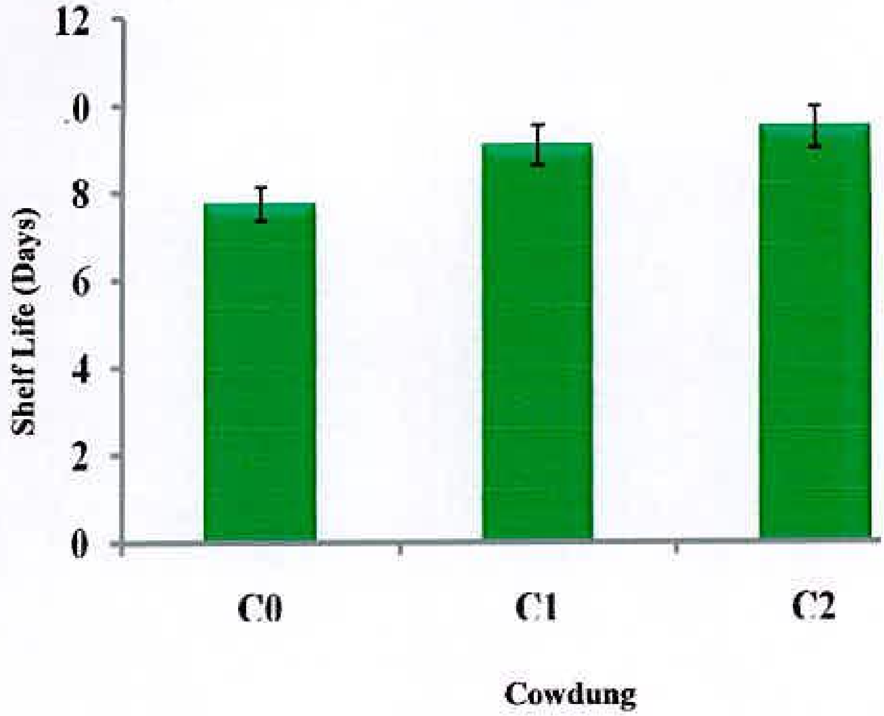


Figure 12. Effect of cowdung on shelf life of tomato in open condition

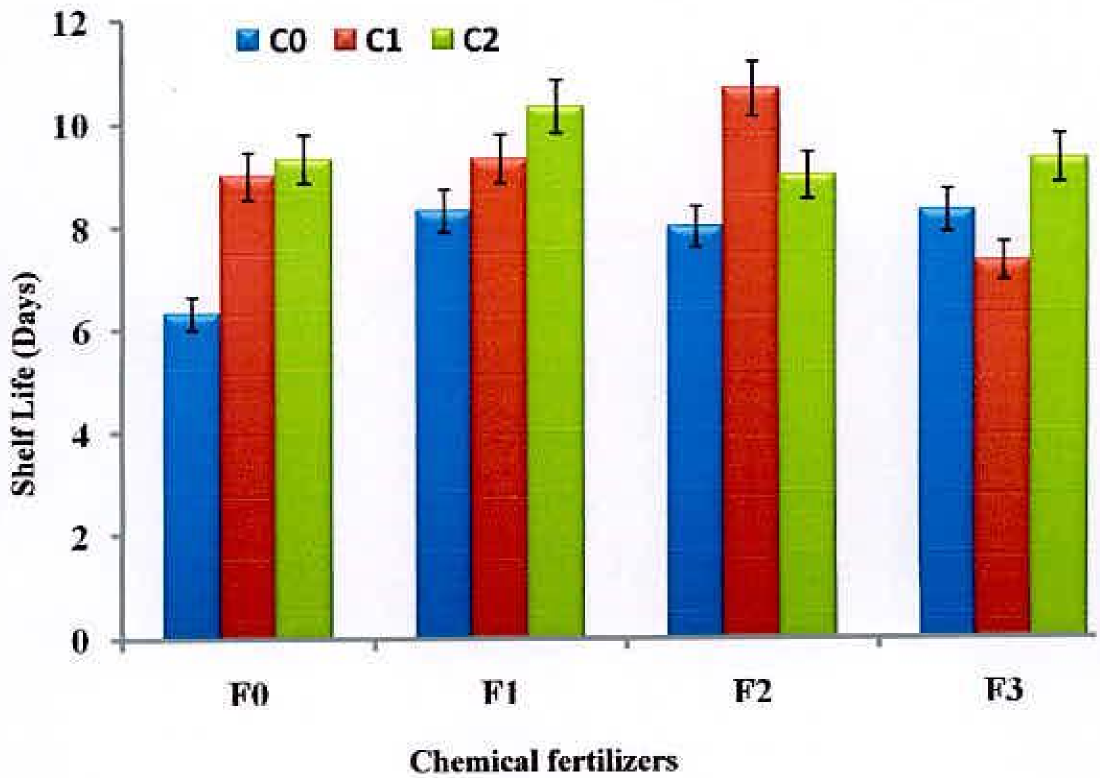


Figure 13. Interaction effect of chemical fertilizers and cowdung on shelf life of tomato in open condition

4.3.2 Shelf life in earthen pot

The variation in shelf life of tomato in earthen pot condition varied significantly due to the application of different levels of chemical fertilizers (Figure 14 and appendix XXIV). The highest shelf life was recorded from the treatment F_3 (10.44 days) which was statistically similar with the treatment F_2 (10.00 days), while the lowest was observed from the treatment F_1 (9.33 days) which was statistically identical with the treatment F_0 (9.67 days). These results were found similar with the findings of Chandra *et al.* (2003), Yang *et al.* (2005) and Salam *et al.* (2009).

Figure 15 and appendix XXIV results of shelf life of tomato in earthen pot showed statistically significant for the application of different levels of cowdung. The highest shelf life of tomato was recorded from the treatment C_1 (10.67 days) which was closely followed by the treatment C_2 (10.00 days), whereas the lowest shelf life of tomato was observed from the treatment C_0 (8.92 days). Zhai *et al.* (2009) and Saliou *et al.* (2009) reported that the effects of organic manures, the cow and sheep manures showed more dry matter to tomato fruit conferring them a longer shelf life.

The significant difference also had in terms of shelf life in earthen pot of tomato due to interaction effect of chemical fertilizers and cowdung (Figure 16 and appendix XXIV). The highest shelf life in earthen pot of tomato was recorded from the treatment F_0C_2 (11.33 days), which was statistically identical with the treatments F_1C_1, F_1C_2 and F_2C_1 (11.00 days), and the lowest shelf life of tomato in earthen pot was recorded from the treatment F_0C_0 (7.67 days). These results were also found similar with Krishna and Krishnappa (2002).

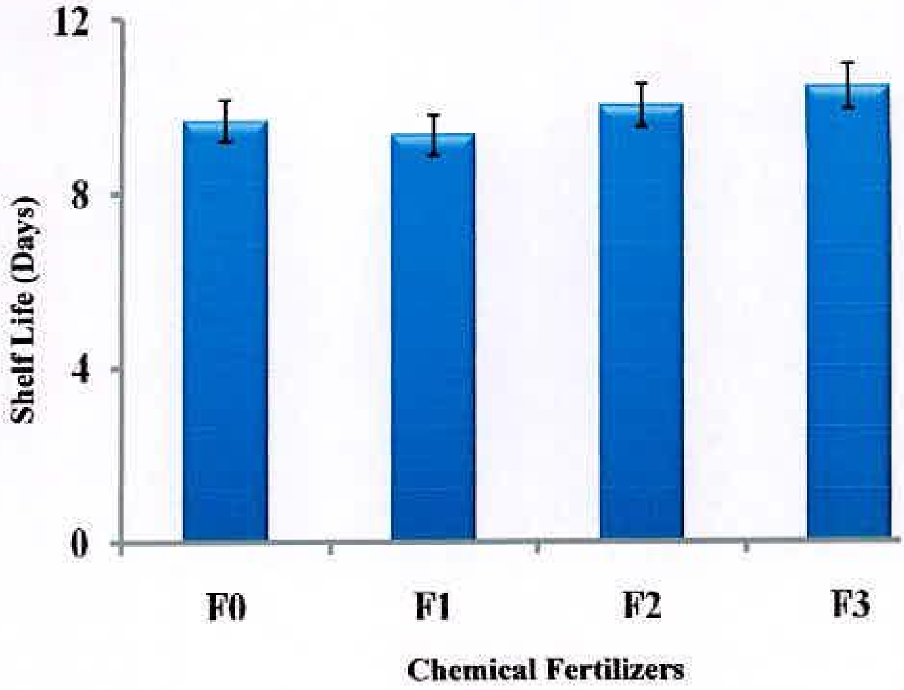


Figure 14. Effect of chemical fertilizers on shelf life of tomato in earthen pot

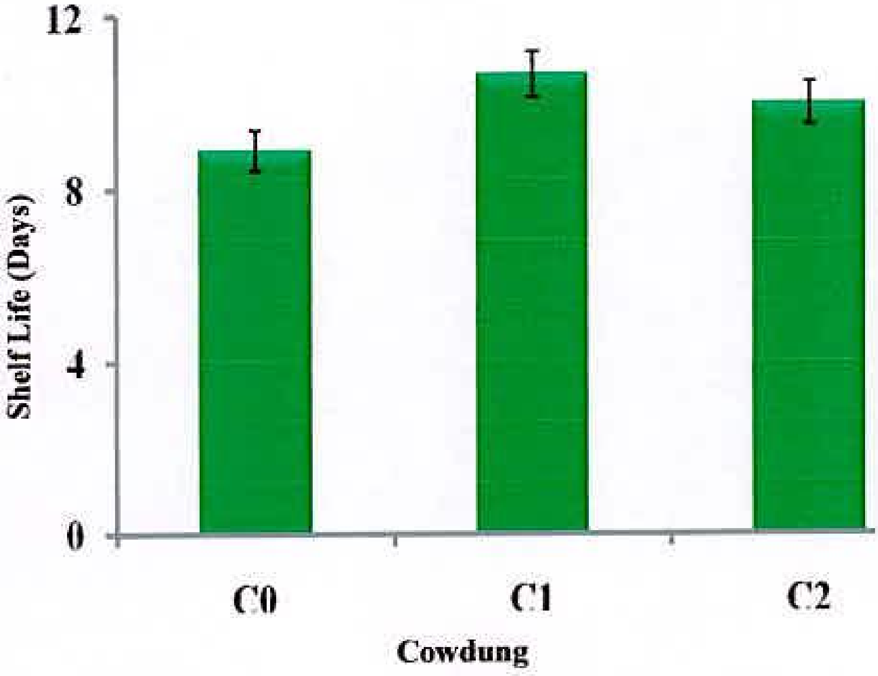


Figure 15. Effect of cowdung on shelf life of tomato in earthen pot

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

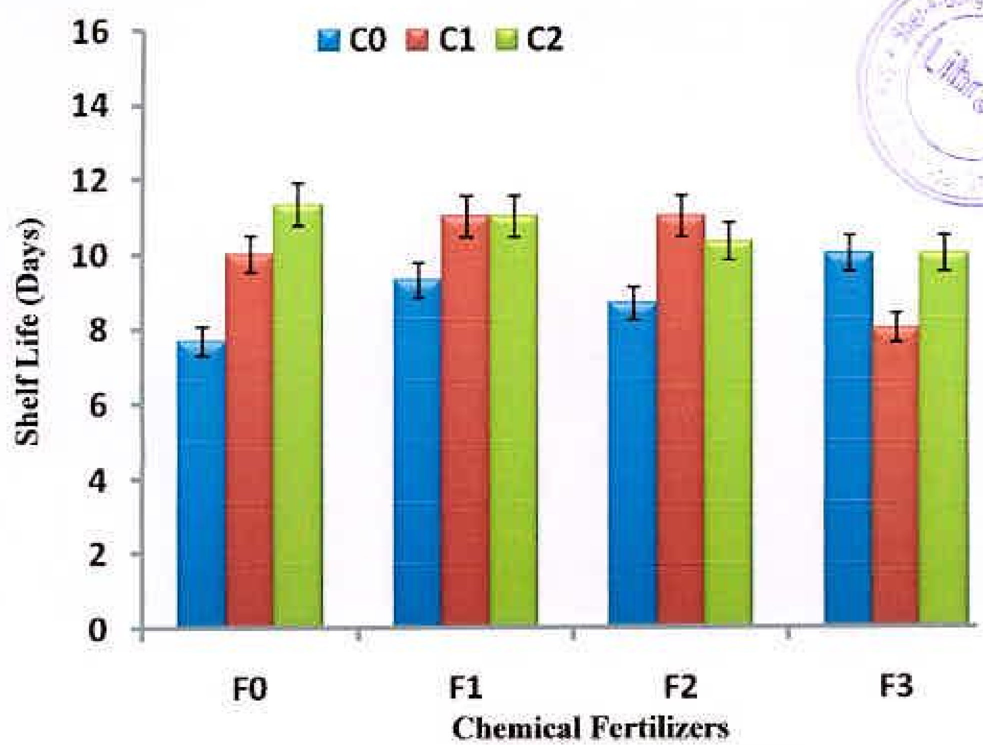


Figure 16. Interaction effect of chemical fertilizers and cowdung on shelf life of tomato in earthen pot

4.3.3 Total soluble solid (TSS)

There had significant variation with the application of different levels of chemical fertilizers of total soluble solid (TSS) of tomato (Figure 17 and Appendix XXIV). The highest TSS of tomato was recorded from the treatment F_2 (4.84%) which was statistically similar with the treatments F_1 (4.71%) and F_3 (4.40%), while the lowest TSS was found from the treatment F_0 (4.03%). These results were similar with Chandra *et al.* (2003). It is reported that inorganic fertilizers affect the content of TSS in tomato.

The effect of different levels of cowdung in terms of total soluble solid (TSS) in tomato found statistically significant (Figure 18 and Appendix XXIV). The highest total soluble solid (TSS) of tomato was obtained from the treatment C_1 (4.84%) which was statistically identical with the treatment C_2 (4.73%), whereas the lowest total soluble solid (TSS) was recorded from the treatment C_0 (3.91%). These results were found similar with Krishna and Krishnappa (2002), who recorded the highest values for total soluble solids of tomato with the application of NPK.

Figure 19 and Appendix XXIV showed that interaction effect of chemical fertilizers and cowdung varied significant differences for total soluble solid (TSS) of tomato. The highest total soluble solid (TSS) of tomato was observed from the treatment F_2C_2 (5.30%), while the lowest was recorded from the treatment F_0C_0 (3.76%). These observations were similar with the findings of Patil *et al.* (2004) and Shukla *et al.* (2006), they observed that the application of recommended rates of NPK with farmyard manure and vermicompost was superior to total soluble solids content in tomato.

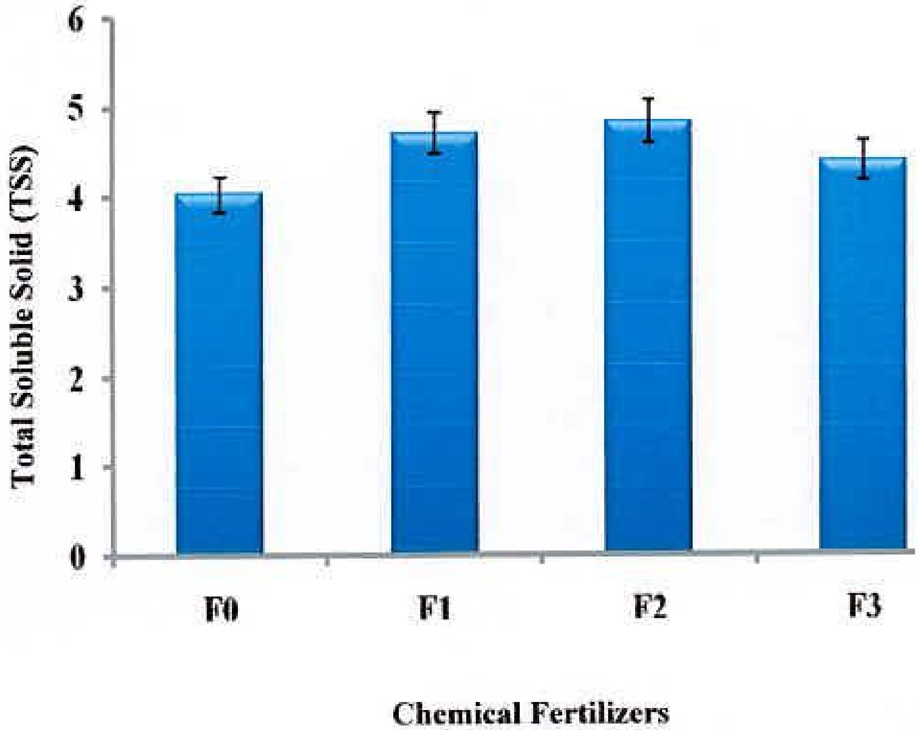


Figure 17. Effect of chemical fertilizers on total soluble solid (TSS) of tomato

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

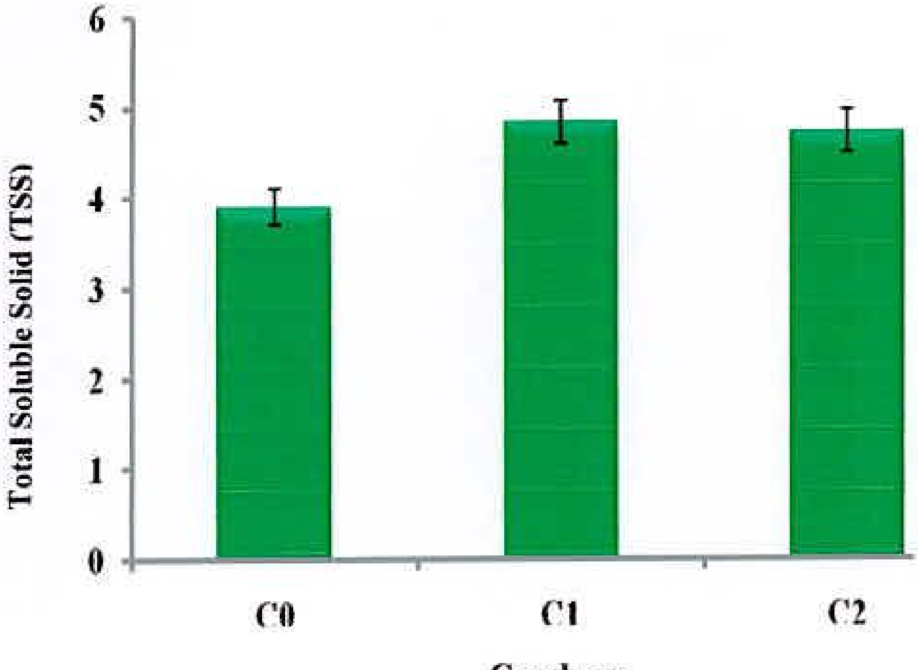


Figure 18. Effect of cowdung on total soluble solid (TSS) of tomato

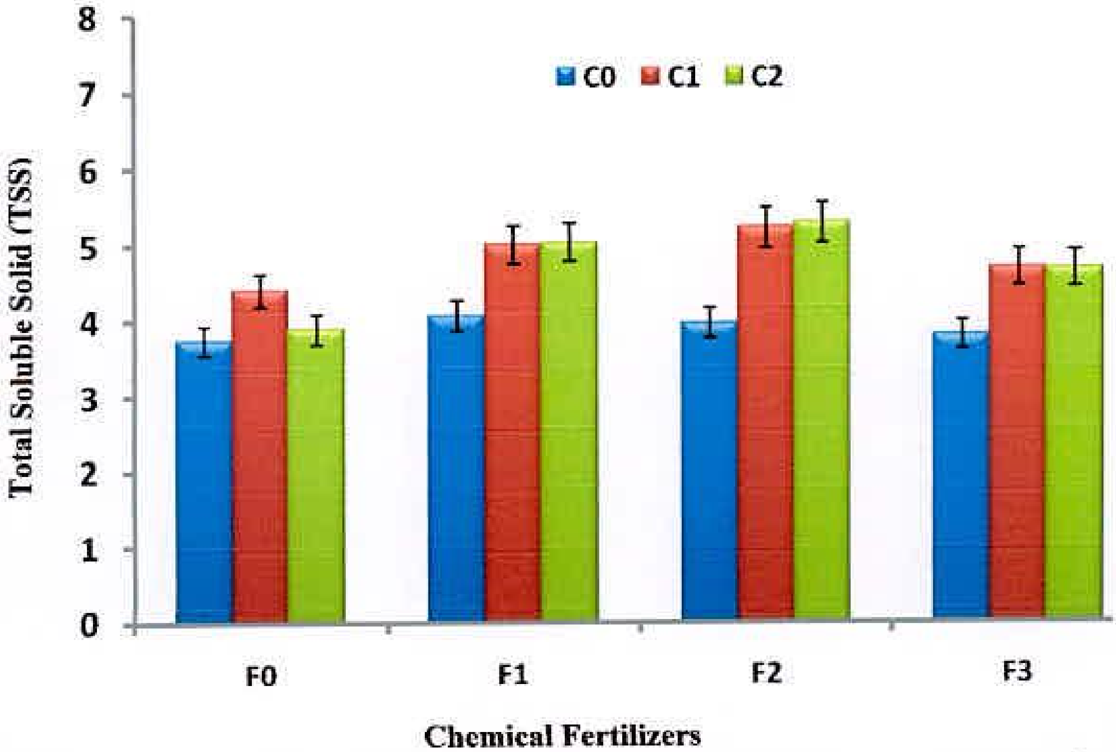


Figure 19. Interaction effect of chemical fertilizers and cowdung on total soluble solid (TSS) of tomato

F_0: No chemical fertilizers (Control)
F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha
F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha
F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha

C_0: No cowdung (Control)
C_1: 5 ton cowdung/ha
C_2: 10 ton cowdung/ha

Chapter V

Summary and Conclusion

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was conducted in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2008 to April 2009 to study the phenology, yield and quality of tomato *(Lycopersicon esculentum)* with different doses of fertilizers and cowdung. The two factorial experiment was laid out in a randomized complete block design (RCBD) with three replications. The experiment consisted of two factors, *viz.* factor A: Four levels of chemical fertilizer; F_0: control; F_1: 150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha; F_2: 200 kg N + 150 kg P_2O_5 + 125 kg K_2O + 15 kg S/ha and F_3: 250 kg N + 200 kg P_2O_5 + 150 kg K_2O + 20 kg S/ha and factor B: Three levels of cowdung as C_0: Control; C_1: 5 ton cowdung/ha and C_2: 10 ton cowdung/ha with the following treatment combinations of F_0C_0, F_0C_1, F_0C_2, F_1C_0, F_1C_1, F_1C_2, F_2C_0, F_2C_1, F_2C_2, F_3C_0, F_3C_1 and F_3C_2. The urea, TSP, MP and gypsum were used as a source of N, P_2O_5, K_2O and S, respectively. The seedlings of tomato var. BARI Tomato-6 (chaiti) were raised at the nursery of the University farm. Five plants were randomly selected from each unit plot for considering the collection of data.

Different combinations of chemical fertilizers and cowdung showed significant variation in respect of most of the phenological characters, yield and quality characters of tomato. In this study, plant height, number of leaves per plant and number of branches per plant, highest number of flower cluster per plant, maximum number of flowers per plant, number of flowers per cluster, number of fruits per plant, fruit size and yield per hectare, shelf life and total soluble solid were increased at different days after transplanting with increasing doses of both chemical and organic fertilizers. Interaction effects of chemical fertilizers and cowdung showed significant variation in respect of most of the phenological characteristics. The tallest plants (28.06 cm), (64.80 cm), and (127.04 cm) were found from F_1C_2 treatment at 30, 50 DAT and final harvest, respectively whereas the shortest plants (20.45 cm, 38.29 cm, 53.32 cm) were found from control treatments.

During the period of experiment the shortest plant was recorded from F_1C_0 (53.32 cm) and F_0C_2 treatment (101.42 cm) at 50 DAT and harvest, respectively. At 30 and 40 DAT, the highest number of leaves per plant was recorded from F_1C_2 treatment (10.27 and 24.60), the lowest number of leaves was observed from F_0C_0 (6.07) and F_0C_2 (15.00) treatments. Moreover, at 50 and 60 DAT showed the best performance in the F_2C_1 treatment (39.67 and 54.03) and at harvesting stage, the highest number of leaves per plant observed from F_2C_1 (77.53) treatment. On the other hand, at 40 and 50 DAT, the lowest number of leaves was also observed from F_0C_2 (15.00) and F_0C_1 (31.80) treatments. The maximum number of branches per plant was obtained from F_1C_2 (4.00) treatment, at 50 and 60 DAT, the highest result was found from F_2C_1 (7.50, 10.93) treatment. But at final harvesting stage, the highest number of branches was recorded from F_2C_2 (16.07) treatment and consequently, the minimum number was observed from F_0C_0 (2.00, 2.77, 3.93, 5.07 and 8.63) treatment where no fertilizers and manure were applied. The minimum days from transplanting to 1st flowering were recorded from F_2C_2 (40.80 days) treatment and the maximum days from transplanting to 1st flowering were observed from F_0C_0 (50.73 days) treatment. The minimum days from transplanting to 1st harvesting were recorded from F_2C_1 (76.30 days), while the maximum days were recorded from F_3C_2 (88.97 days) treatment combinations.

Interaction effects of chemical fertilizers and cowdung showed significant variation in respect of most of the yield contributing characteristics. The maximum number of flower cluster (11.70) and flowers per plant (78.30) were recorded from F_1C_2 treatment. In contrast, the lowest number of flower cluster (6.90) and flowers (26.54) per plant of tomato was recorded from F_0C_0 treatment. The maximum number of flowers per cluster (7.17), fruits per cluster (6.83) and fruits per plant (53.70) were recorded from F_2C_1 treatment and the minimum were recorded with control treatment. The maximum weight of individual fruit was recorded from F_2C_2 (92.43 g) treatment, which is statistically similar with F_1C_2 (91.06 g) treatment and the lowest weight of individual fruit was observed from F_0C_0 (64.13 g) treatment. The highest yield of tomato per hectare was recorded from F_2C_1 (67.93 t/ha) treatment, while the lowest yield of tomato per hectare was obtained from F_0C_0 (28.47 t/ha) treatment. The maximum dry matter content in plant was observed from F_2C_1 (16.15) from F_3C_1 treatment. Furthermore, the minimum dry matter content in plant was found from F_0C_0 treatment (9.08%, 11.54%, and 12.42%) at different DAT. The highest viable and lowest non viable pollen was recorded from F_2C_2 treatment (70.00%) and (30%), respectively. the lowest viable and highest non-viable pollen were obtained from F_3C_0 treatment (44.50%) and (52.50%), respectively.

Different combinations of chemical fertilizers and cowdung showed significant variation in respect of qualitative characteristics. The highest shelf life was found from F_2C_1 treatment (10.67 days) consequently, the lowest shelf life of tomato was recorded from F_0C_0 treatment (6.33 days). The maximum total soluble solid (TSS) of tomato was observed from F_2C_2 treatment (5.30%), while the minimum was recorded from F_0C_0 treatment (3.76%).

From the view point, the chemical fertilizers F_2 treatment (200 Kg N + 150 Kg P_2O_5 + 125 Kg K_2O + 15 kg S/ha) performed better in phenology and yield of tomato. The cowdung, C_1 treatment (5 ton cowdung/ha) were found better in respect of phenology and yield but C_2 treatment (10 ton cowdung/ha) responded better in phenology and quality of tomato. Both the treatment combinations, F_1C_2 (150 kg N + 100 kg P_2O_5 + 100 kg K_2O + 10 kg S/ha and 10 ton cowdung/ha) and F_2C_1 (200 Kg N + 150 Kg P_2O_5 + 125 Kg K_2O + 15 Kg S/ha and 5 ton cowdung/ha) showed almost better performance in respect of phenology, yield and quality of tomato. No significant differences were observed between F_1C_2 and F_2C_1 treatment in respect of phenology, yield and quality of tomato. The treatment combinations of F_1C_2 might be recommended for tomato production rather than F_2C_1, due to sources of plant nutrients through cowdung is better than inorganic sources to keep safe environment.

RECOMMENDATIONS

Taking into account the limitations of the study, the following suggestions may be considered for further studies.

1. By taking further different levels of chemical fertilizers along with different compositions of cowdung to find the perfect combinations of inorganic and organic fertilizers to promote the growth, yield and quality of tomato.

2. Such research works should be conducted in different AEZs of Bangladesh to recommend the proper doses of manures and fertilizers.

Chapter VI

References

CHAPTER 6

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Chapter VII

Appendices

CHAPTER 7

APPENDICES

Appendix I. The morphological, physical and chemical characteristics of the soil of the experimental site:

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
AEZ	Madhupur Tract (AEZ 28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium high land
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
pH	5.6
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November 2008 to April 2009

Month	*Air temperature (°C)		*Relative humidity (%)	*Rain fall (mm) (total)
	Maximum	Minimum		
November, 2008	25.82	16.04	78	00
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11
April, 2009	32.4	23.1	67	142

* Monthly average, ** Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan, Dhaka, Bangladesh

Appendix III. Map showing the experimental site

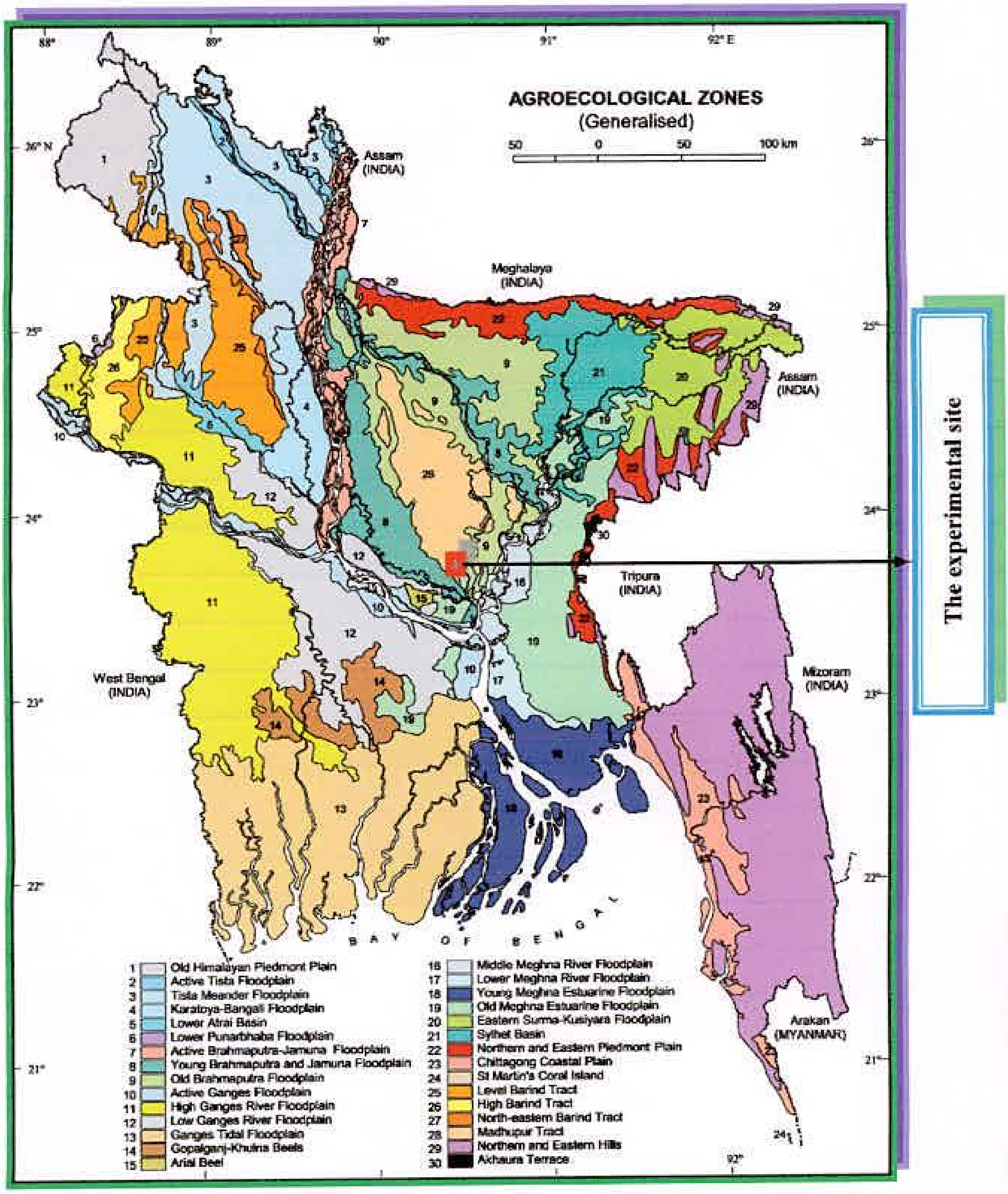


Figure. Map showing the experimental site under study

Appendix IV. Panoramic view of the experimental plot (Plate No.: 01)

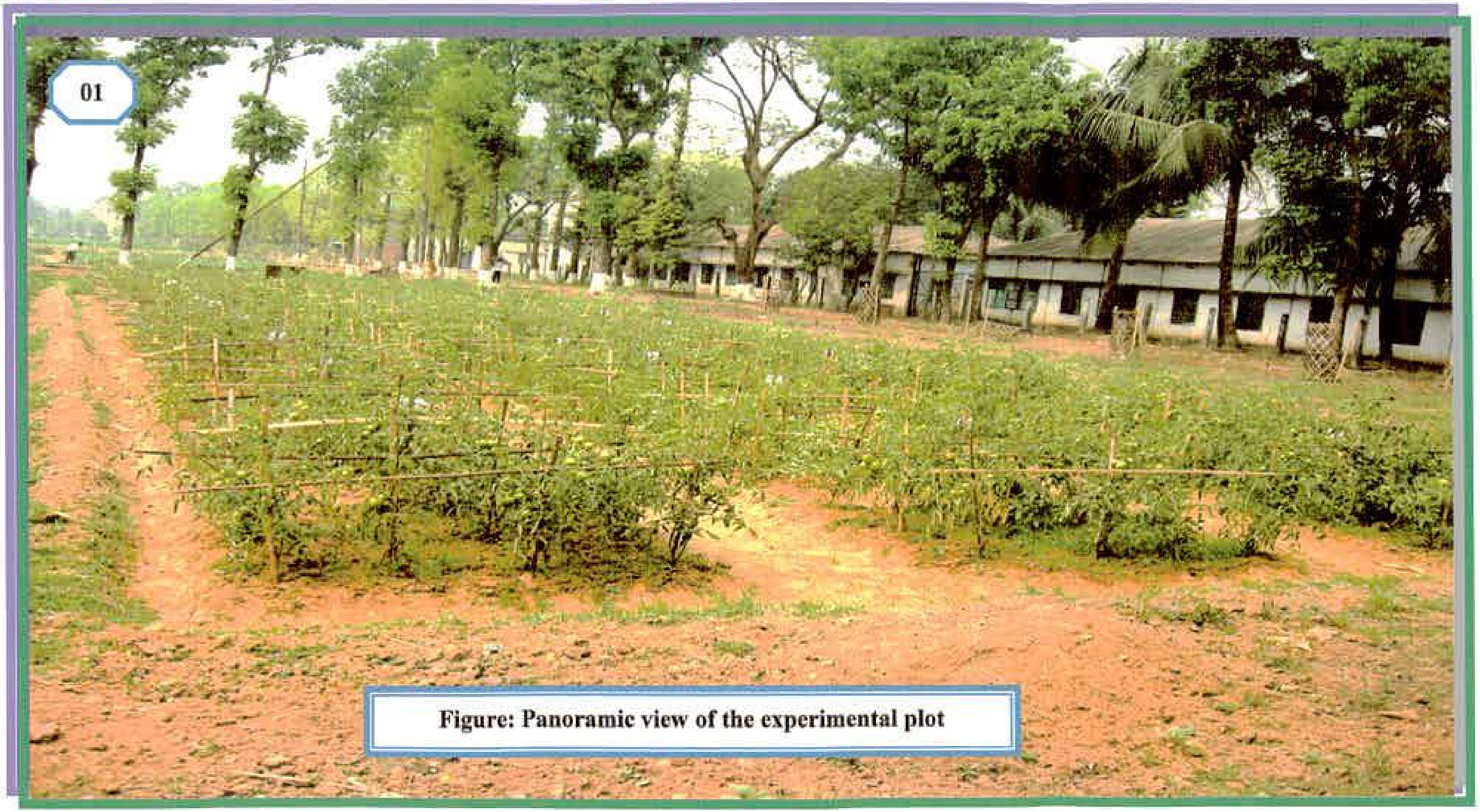


Figure: Panoramic view of the experimental plot

Appendix V. Variation of plant height in response of chemical fertilizers and cowdung in different plots (Plate No.: 02-05)

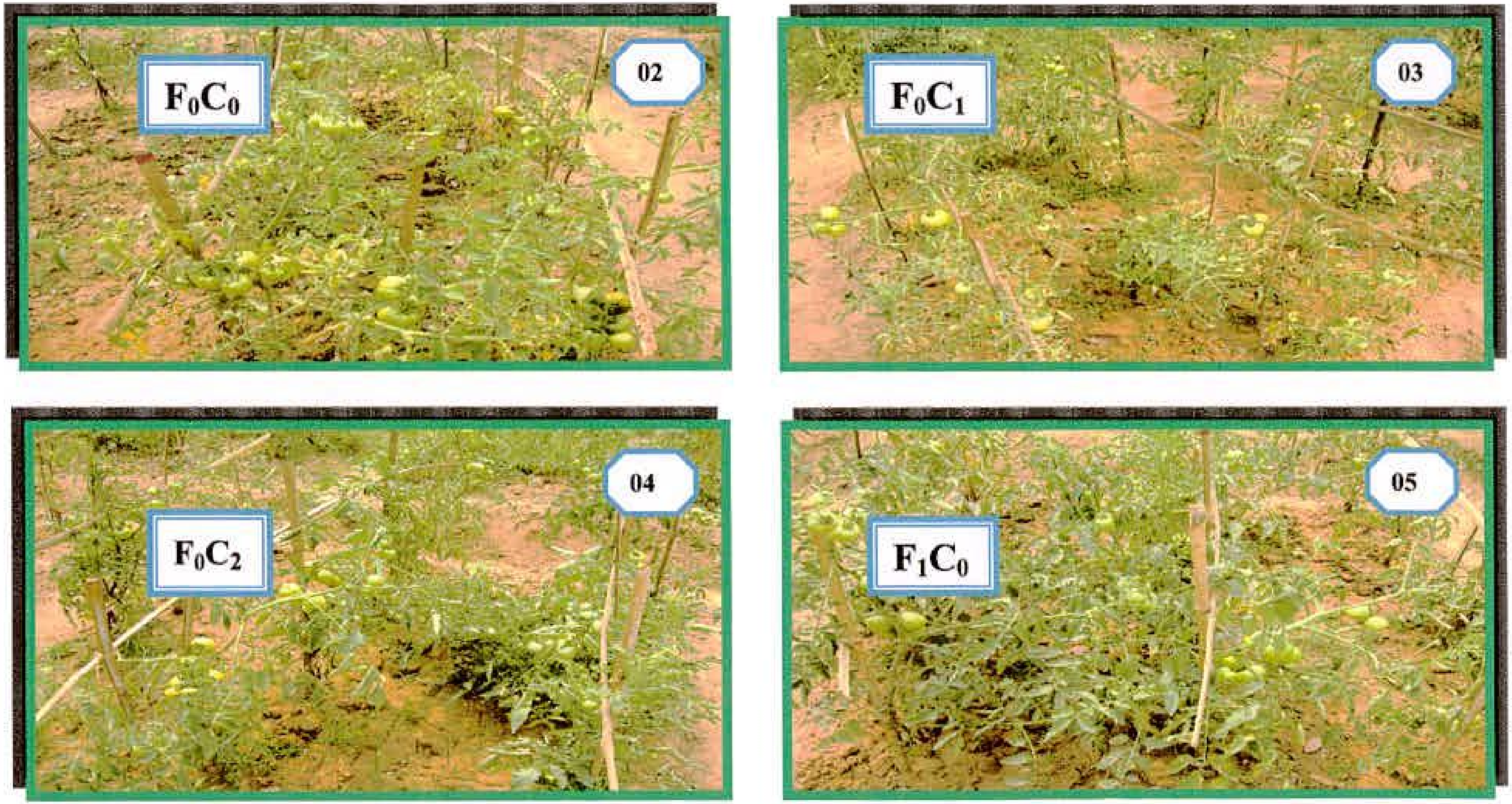


Figure: Plant height in response to chemical fertilizers and cowdung

Appendix VI. Variation of plant height in response of chemical fertilizers and cowdung in different plots (Plate No.: 06-09)

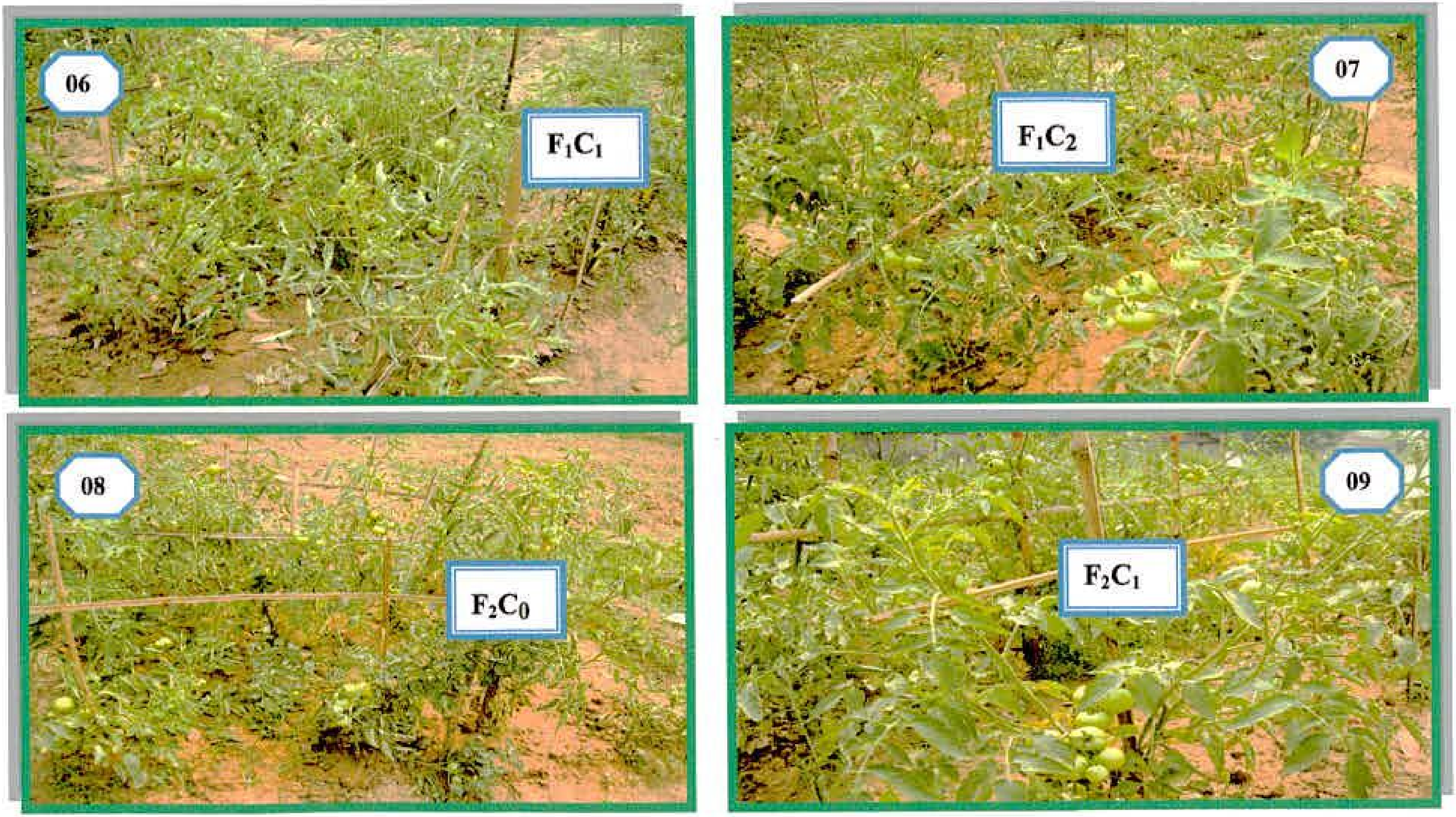


Figure: Plant height in response to chemical fertilizers and cowdung

Appendix VII. **Variation of plant height in response of chemical fertilizers and cowdung in different plots** (Plate No.: 10-13)

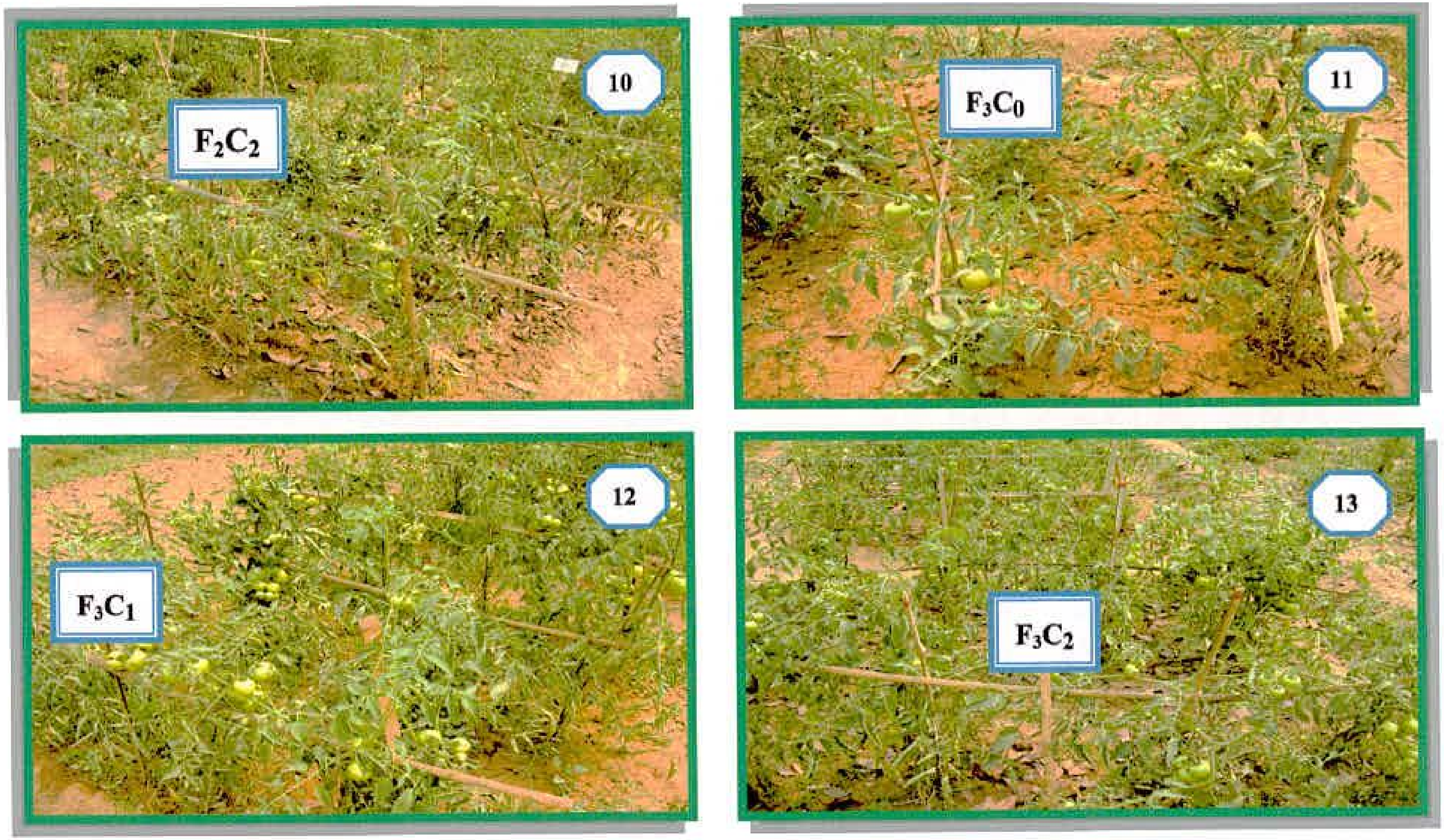


Figure: Plant height in response to chemical fertilizers and cowdung

Appendix VIII. **Comparison between treatments as influenced by chemical fertilizers and cowdung on plant height** (Plate No.: 14-15)

Figure: Comparison between F_3C_2 and F_0C_0 treatments as influenced by chemical fertilizers and cowdung on plant height

Appendix IX. Comparison between treatments as influenced by chemical fertilizers and cowdung on plant height (Plate No.: 16-17)

Figure: Comparison between F_3C_2 and F_0C_0 treatments as influenced by chemical fertilizers and cowdung on plant height

Appendix X. Number and size of fruits in different plots in the field (Plate No.: 18-21)

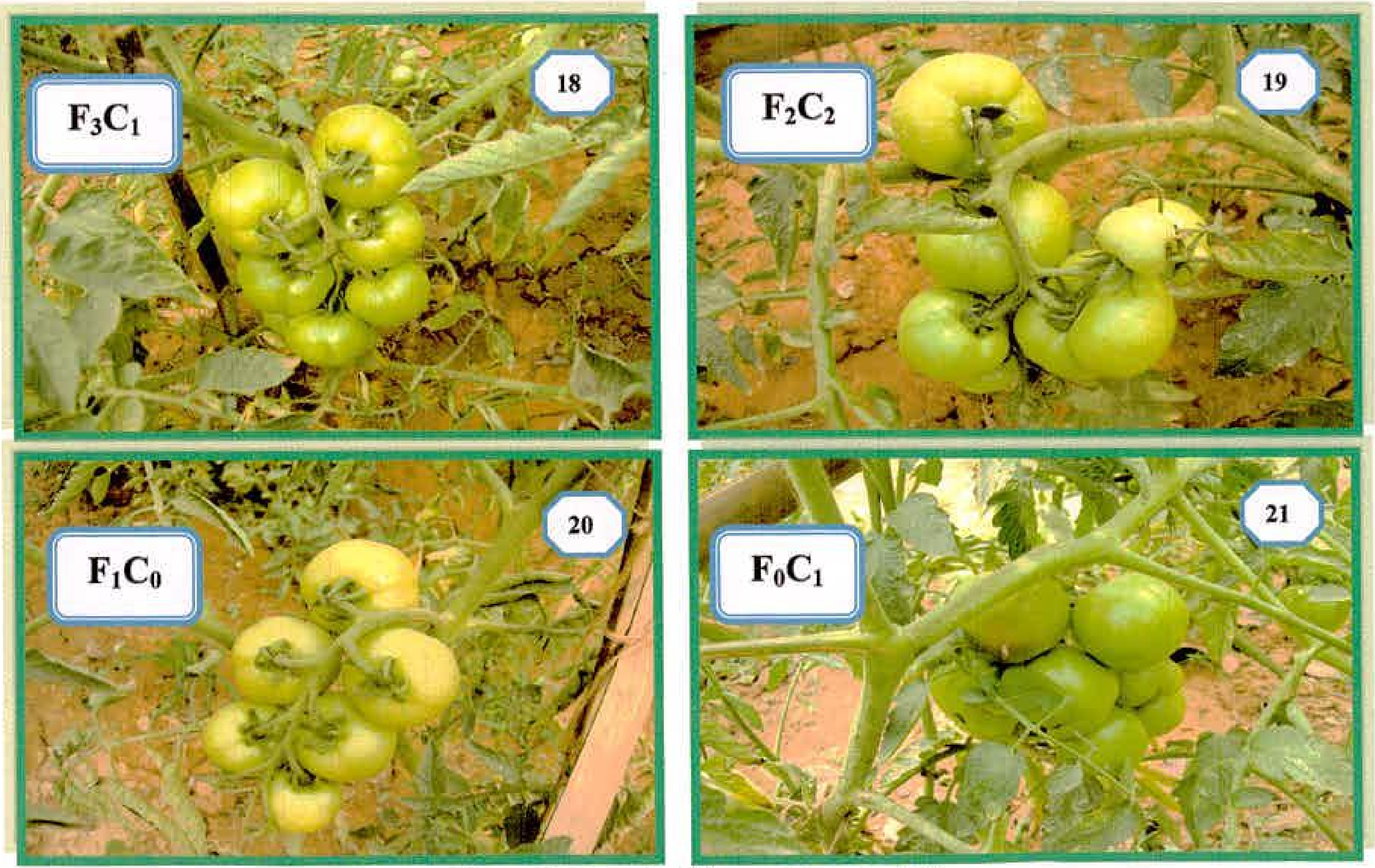


Figure: Fruit size in different plots in the field

Appendix XI. Number and size of fruits in different plots in the field (Plate No.: 22-25)

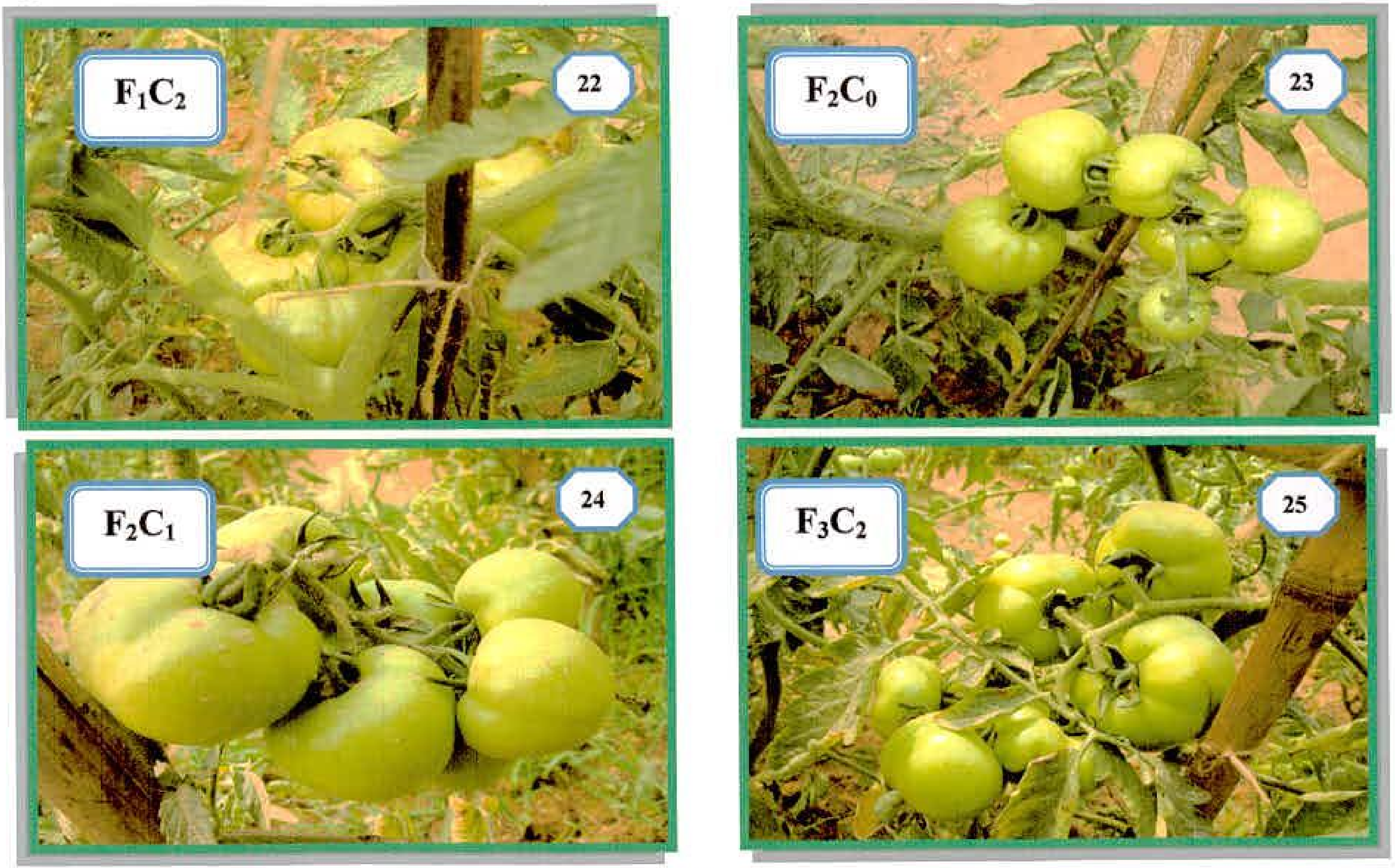


Figure: Fruit size in different plots in the field

Appendix XII. Number and size of fruits in different plots in the field (Plate No.: 26-29)

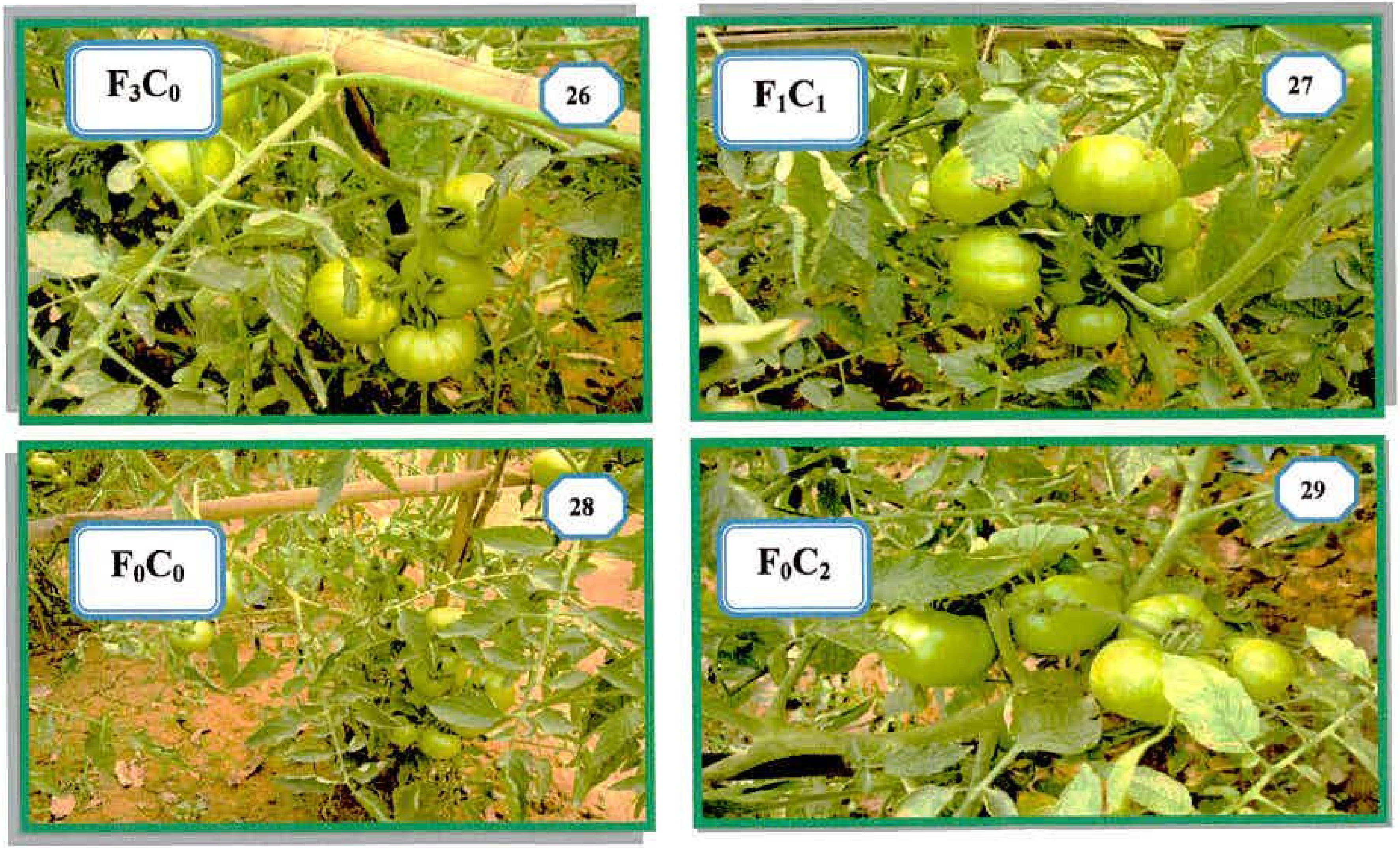


Figure: Fruit size in different plots in the field

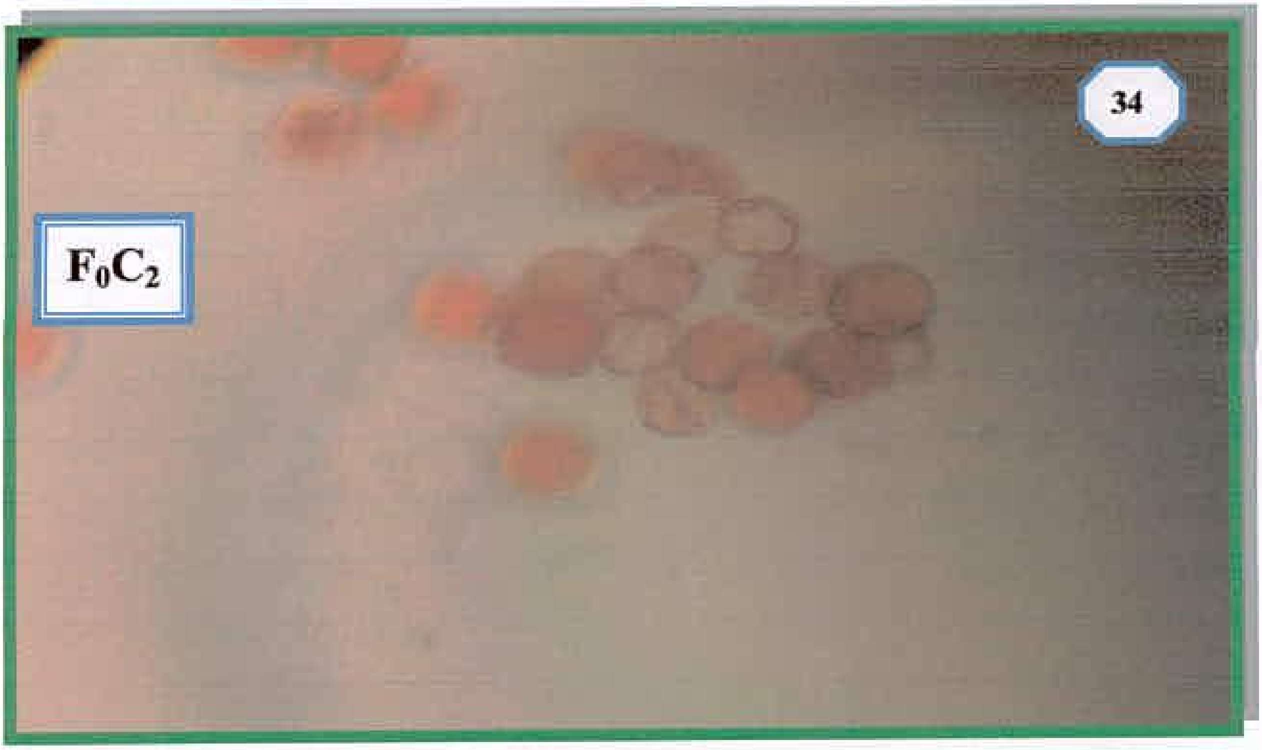
Appendix XIII. Comparison between control and best treatments in respect of number of fruits of tomato (Plate No.: 30-31)

Figure: Comparison between control and best treatments in respect of number of fruits of tomato

Appendix XIV. **Comparison between control and best treatments in respect of number of fruits of tomato** (Plate No.: 32-33)

Figure: Comparison between control and best treatments in respect of number of fruits of tomato

Appendix XV. Comparison between viable and non-viable pollen in the middle level yield potential treatments of tomato plant (F_0C_2 and F_0C_0) (Plate No.: 34-35)



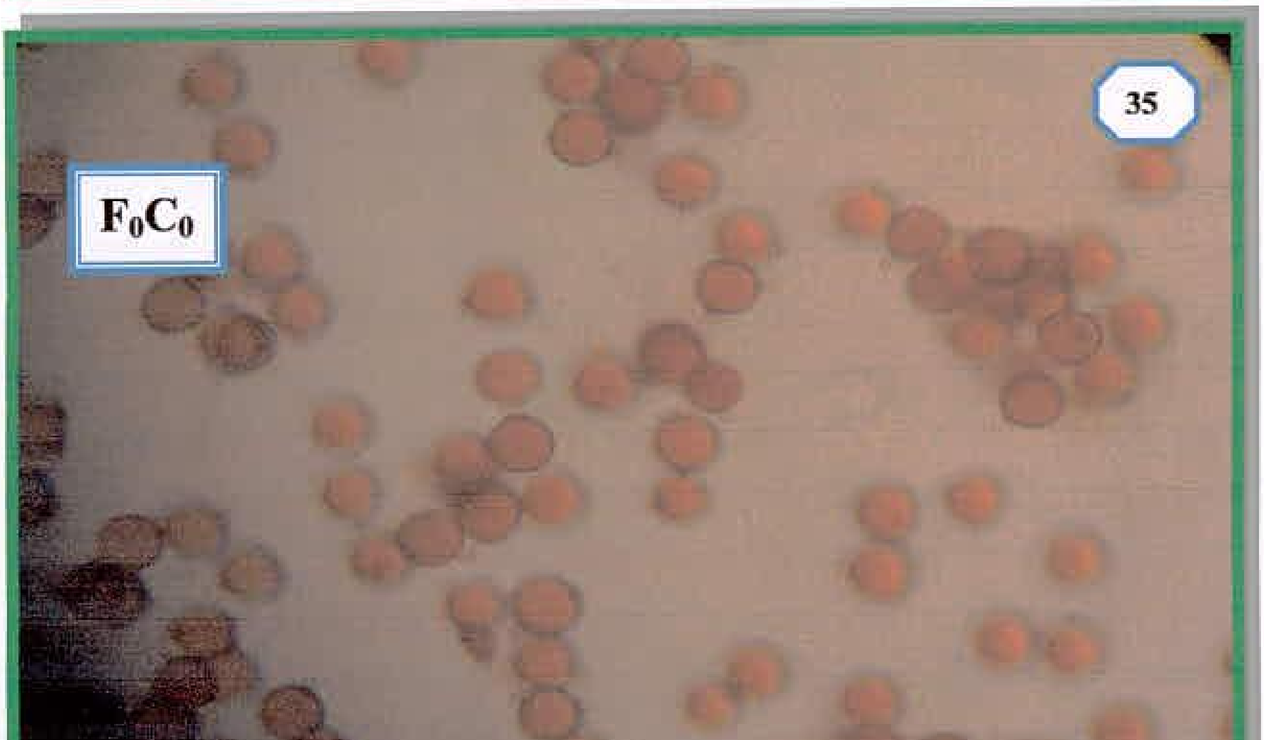


Figure : Comparison between viable and non-viable pollen in the middle level yield potential treatments (F_0C_2 and F_0C_0)

Appendix XVI. **Comparison between viable and non-viable pollen in the middle level yield potential treatments of tomato plant (F_1C_2 and F_1C_1)** (Plate No.: 36-37)

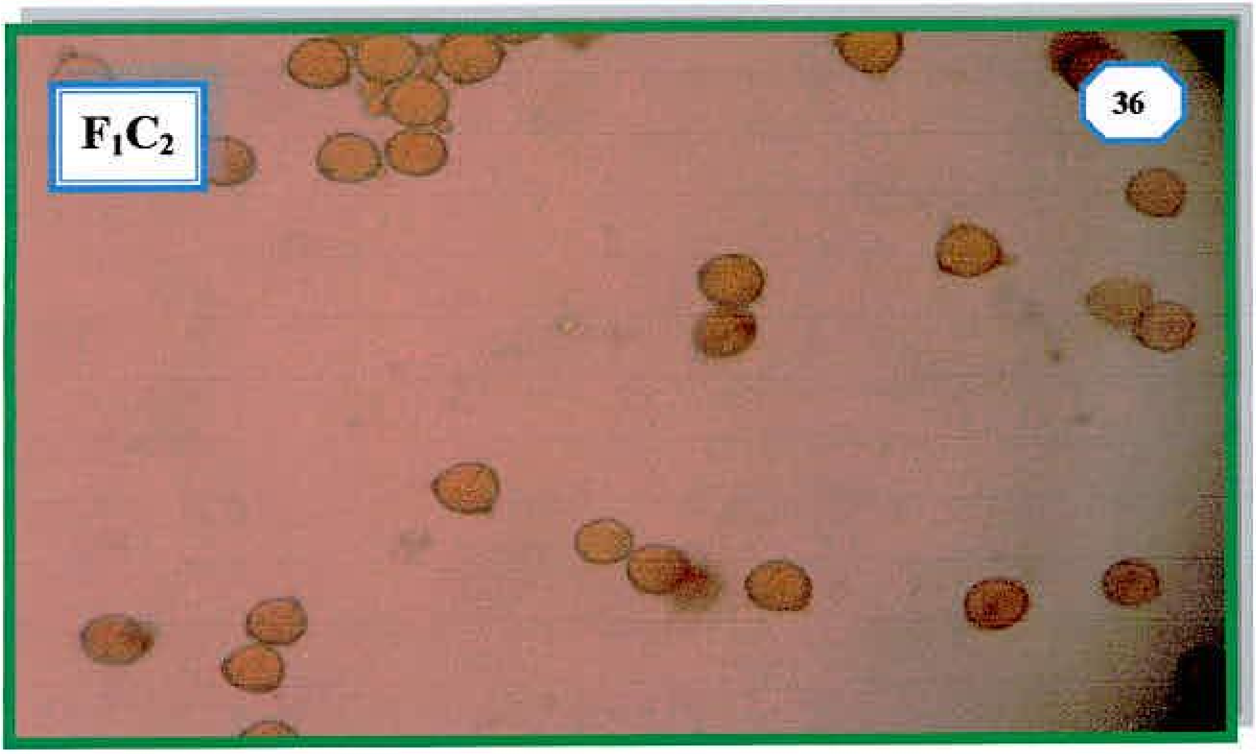
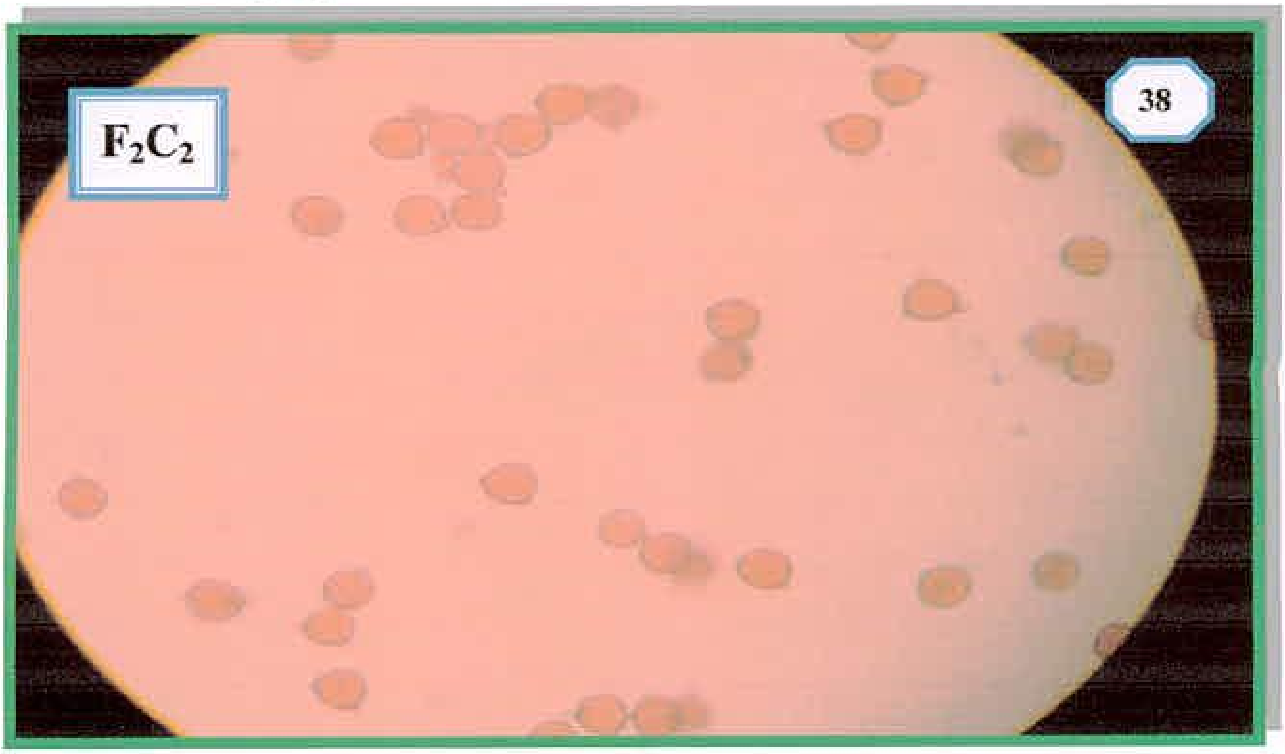


Figure : Comparison between viable and non-viable pollen in the middle level yield potential treatments (F_1C_2 and F_1C_1)

Appendix XVII. Comparison between viable and non-viable pollen in the middle level yield potential treatments of tomato plant (F_2C_2 and F_3C_1) (Plate No.: 38-39)



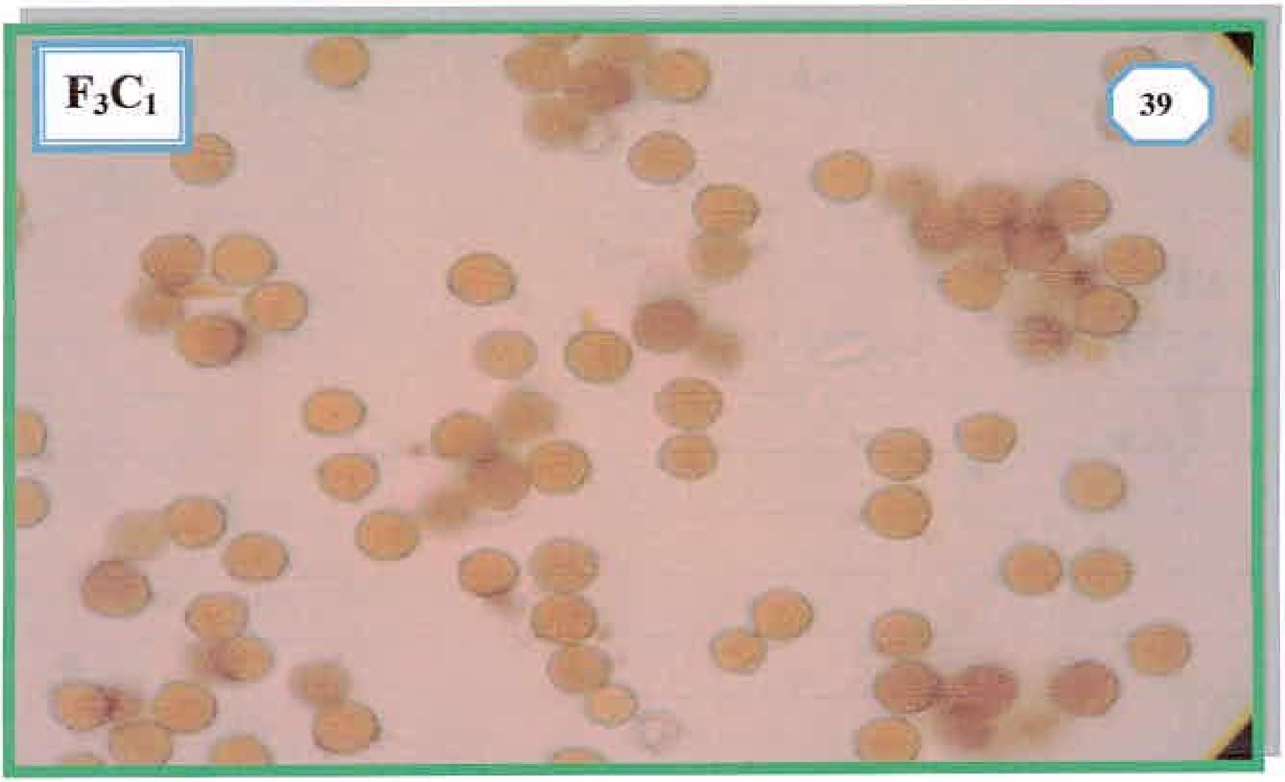


Figure : Comparison between viable and non-viable pollen in the middle level yield potential treatments of tomato plant (F_2C_2 and F_3C_1)

Appendix XVIII. **Analysis of variance of the data on plant height of tomato as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAT	40 DAT	50 DAT	60 DAT	Harvest
Replication	2	0.844	0.365	0.087	11.862	1.522
Chemical fertilizer (A)	3	9.916**	11.264**	28.640**	77.265**	111.528**
Cowdung (B)	2	64.606**	80.202**	144.884**	615.311**	843.900**
Interaction (A × B)	6	3.793**	4.885**	15.862**	38.086**	37.074**
Error	22	1.109	1.377	2.797	6.868	10.314

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XIX. **Analysis of variance of the data on number of leaves per plant of tomato as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square				
		Number of leaves per plant at				
		30 DAT	40 DAT	50 DAT	60 DAT	Harvest
Replication	2	0.002	1.761	0.826	1.848	10.039
Chemical fertilizer (A)	3	1.529**	14.766**	50.052**	66.706**	210.288**
Cowdung (B)	2	20.481**	82.401**	185.945**	442.172**	1295.326**
Interaction (A × B)	6	1.031**	6.994**	17.142**	24.297**	210.721**
Error	22	0.194	1.790	3.866	3.837	19.971

**: Significant at 0.01 level of probability;

Appendix XX. **Analysis of variance of the data on number of branches per plant of tomato as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square				
		Number of branches per plant at				
		30 DAT	40 DAT	50 DAT	60 DAT	Harvest
Replication	2	0.008	0.002	0.069	0.286	0.271
Chemical fertilizer (A)	3	1.000**	2.009**	1.605**	3.615**	7.644**
Cowdung (B)	2	4.398**	7.016**	14.235**	37.393**	53.027**
Interaction (A × B)	6	0.766**	1.037**	0.631*	2.332**	4.610**
Error	22	0.094	0.191	0.213	0.653	0.527

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXI. **Analysis of variance of the data on yield contributing characters of tomato as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square					
		Days required to 1st flowering from transplanting	Days required to 1st harvesting from transplanting	Number of flower cluster per plant	Number of flowers per cluster	Number of flowers per plant	Number of fruits per cluster
Replication	2	0.231	1.647	0.481	0.019	28.375	0.053
Chemical fertilizer (A)	3	43.178**	21.650**	2.209**	2.577**	435.477**	3.641**
Cowdung (B)	2	18.791**	44.360**	34.903**	17.009**	4224.876**	2.091**
Interaction (A × B)	6	21.227**	48.249**	1.230*	2.368**	426.988**	1.368**
Error	22	3.538	4.236	0.443	0.309	22.217	0.095

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXII. **Analysis of variance of the data on yield contributing characters and yield of tomato as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square				
		Number of fruits per plant	Fruits length (cm)	Fruits diameter (cm)	Weight of Individual fruit (g)	Yield (ton/ha)
Replication	2	8.116	0.018	0.001	22.595	3.174
Chemical fertilizer (A)	3	487.154**	2.590**	1.730**	193.280**	293.787**
Cowdung (B)	2	993.827**	5.885**	2.357**	659.532**	1135.488**
Interaction (A × B)	6	216.700**	0.394**	0.517**	48.217*	103.512**
Error	22	9.749	0.315	0.088	26.413	6.502

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXIII. **Analysis of variance of the data on dry matter content of tomato plant as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square Dry matter content per plant (%) at		
		40 DAT	50 DAT	60 DAT
Replication	2	0.205	0.706	0.954
Chemical fertilizer (A)	3	10.821**	13.054**	16.364**
Cowdung (B)	2	3.173**	3.870**	17.341**
Interaction (A × B)	6	0.833*	1.173*	6.792*
Error	22	0.385	0.820	2.181

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix XXIV. **Analysis of variance of the data on pollen viability, shelf life and total soluble solid of tomato as influenced by different doses of chemical fertilizers and cowdung**

Source of variation	Degrees of freedom	Mean square				
		Pollen viability (%)		Shelf life (days) in		Total soluble solid (TSS)
		Viable	Non-Viable	Open condition	Earthen pot	
Replication	2	1.188	1.188	0.028	0.528	0.023
Chemical fertilizer (A)	3	326.000**	326.000**	3.037**	2.028**	1.178**
Cowdung (B)	2	235.938**	235.938**	10.028**	9.361**	3.131**
Interaction (A × B)	6	174.688**	174.688**	3.176**	4.028**	0.190
Error	22	11.619	11.619	0.361	0.285	0.195

**: Significant at 0.01 level of probability.