EFFECT OF LIGHT INTENSITY AND FERTILIZER MANAGEMENT ON GROWTH AND YIELD OF SUMMER TOMATO (BARI TOMATO-4)

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BY

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This is to certify that the thesis entitled "**Effect of Light Intensity and Fertilizer Management on Growth and Yield of Summer Tomato (BARI Tomato-4)**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by **Rizvi Islam,** Registration Number**:** 09-03704 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma**.**

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

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ABSTRACT

The experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agriculture University, Dhaka, during the period from April to October 2011 to find out the effect of light intensity and fertilizer management on growth and yield of summer tomato. The experiment consisted of two factors. Factor A : Light intensity (three levels)as L_1:50%PAR (Photo-synthetically Active Radiation); L_2:75%PAR;L_3:100%PAR and Factor B: Fertilizer Management (four Levels)as F_0:Control (No fertilizer application);F_1:$Urea_{300kg/ha}$+$TSP_{200\ kg/ha}$+$MP_{150\ Kg/ha}$; F_2:$Urea_{350\ kg/ha}$+$TSP_{250\ kg/ha}$+$MP_{180\ Kg/ha}$; andF_3:$Urea_{400\ kg/ha}$+$TSP_{300\ kg/ha}$+$MP_{210\ Kg/ha}$. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replication. Data on different growth parameter and yield of tomato was recorded. The highest yield (22.65 t/ha) was recorded from F_2 and the lowest yield (19.48 t/ha) was from F_0.The highest yield (22.32 t/ha) from L_2.The lowest yield (20.11 t/ha) from L_1.The highest yield (24.20 t/ha) recorded from F_2L_2.The lowest yield (18.00 t/ha) attained from F_1L_1. The highest (2.39) benefit cost ratio from F_2L_2 and the lowest (1.58) from F_0L_1.It was apparent from the above result that the combination of F_2L_2 was better in production of BARI Tomato-4.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	**FULL NAME**
AEZ	Agro –Ecological Zone
BBS	Bangladesh Bureau of Statistics
DAS	Days After Seeding
FAO	Food and Agriculture Organization
RCBD	Randomized Complete Block Design

TSP	Triple Super Phosphate
UNDP	United Nations Development Program

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CHAPTER I

INTRODUCTION

Tomato (*Solanum esculentum* Mill.) botanically referred to the family Solanaceae is one of the most important and popular vegetable crop. The centre of origin of the genus *Solanum* is the Andean zone particularly Peru-Ecuador-Bolivian areas (Salunkhe *et al*., 1987), but cultivated tomato originated in Mexico. The crop ranks top the list of canned vegetables and next to potato and sweet potato in the world vegetable production (FAO, 1997). In spite of its broad adaptation, production is concentrated in a few area and rather dry area (Cuortero and Fernandez, 1999). 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). Tomato adds flavor to the foods and it is also rich in medicinal value. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. The well riped tomato (per

100 g of edible portion) contains water (94.1%); energy (23 calories); calcium (1.0 gm); magnesium (7.0 mg); vitamin A (1000 IU); ascorbic acid (22 mg); thiamin (0.09 mg); riboflavin (0.03 mg); niacin (0.8 mg) (Mac Gillivary, 1961).

In Bangladesh, the yield of tomato is not enough satisfactory in comparison with other tomato growing countries of the World (Aditya *et al*., 1997). Bangladesh grew tomato in around 15.7 thousand hectares of land in the year 2007-2008 with a total production of 143 thousands tonnes (BBS, 2009). The low yield of tomato in Bangladesh however is not an indication of low yielding potentially of this crop but of the fact that the low yield may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, land for production based on light availability, fertilizer management, pest infestation and improper irrigation facilities. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). The cultivation of tomato requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer.

Light intensity has a great effect on growth and yield of tomato, at higher temperature due to full light intensity, the probability of floral abscision is high after anthesis (Iwahori, 1967). High light intensity accompanied by high temperature are also harmful to fruit-set. High light intensity affects the internal temperature of the reproductive organ of tomato (Kuo *et al*., 1978). Photosynthetically active radiation is the major factor regulating photosynthesis, dry matter production and yield of crops (Rao and Mitra, 1998). Plants grown under shading, showed decreased photosynthesis which ultimately affect yield and fruit quality (Morgan *et al*., 1985). Generally adaptive responses of plant to low irradiance result increased leaf area ratio, stem mass and stem length. On the other hand the adaptive responses also include decreased in leaf thickness and root growth relative to shoot growth (Corre, 1983).

In Bangladesh, fertilizer is the most critical input for increasing crop production and had appropriately been recognized as the central element for agricultural development (Mukhopadhyay *et al*., 1986). More than any other nutrient, nitrogen influences vegetative growth and yield of tomato plant. Nitrogen had the largest effect on yield and quality of tomato (Xin *et al*., 1997). It also promotes vegetative growth, flower and fruit set of tomato (Bose and Som, 1990). Optimum nitrogen increases fruit quality, size, keeping quality, color, taste and acidity of tomato (Sharma and Mann, 1971). It significantly increases the growth and yield of tomato (Banerjee *et al*., 1997). Nitrogen progressively increases the marketable yield (Obreza and Vavrina, 1993) but an adequate supply of nitrogen is essential for vegetative growth, and desirable yield (Yoshizawa *et al*., 1981). Phosphorus is also one of the important essential macro elements for the normal growth and development of plant. The phosphorus requirements vary depending upon the nutrient content of the soil (Bose and Som, 1990). Phosphorus restricted the plant growth and remains immature (Hossain, 1990). Again secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation (Santos *et al*., 2004). Potassium is especially important in a multi nutrient fertilizer application (Brady, 1995). Application of potassium in appropriate time, dose and proper method is prerequisite for any crop cultivation (Islam, 1992). Generally, a large amount of potassium is required for the growth of tomato (Opena *et al*., 1988). It is especially important in a multi nutrient fertilizer application (Brady, 1995). Potassium application increases the flower number, the peduncle length, the fruit set and the number of fruit (Besford and Maw, 1975). It has marked effect on the quality of tomato fruits particularly on color (Wall, 1940 and Ozbun *et al.*, 1967). Potassium also has an important and significant role on balancing physiological activities.

Therefore, to increase yield and to get early production and better quality fruit, an attempt was made to study the effects of light intensity and fertilizer management on plant growth and yield of tomato with the following objectives-

i. To find out the suitable light intensity on growth and yield of tomato;

ii. To investigate the appropriate fertilizer doses on growth and yield of tomato; and

iii. To study the performance of light intensity & fertilizer management on growth and yield of tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the important vegetable crop in Bangladesh and other countries of the world and it has drawn attention by the researchers for it various way of consumptions. But very few research works related to growth, yield and development of tomato due to light intensity and fertilizer management have been carried out. The research work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works and research findings related to the light intensity and fertilizer management in vegetable crops as well as tomato, so far been done at home and abroad, have been reviewed in this chapter under the following heads-

2.1 Effect of light intensity on crop production

Haque *et al*. (2009) conducted an experiment at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Bottle gourd cv. High-green (hybrid) was grown to investigate the morpho-physiological changes and yield performance under four different levels of light (100, 75, 50 and 25% PAR). It was observed that some of the morphological characters like main stem length, internode length and individual leaf area increased, whereas main stem diameter and numbers of leaves per plant decreased due to the reduced light levels. At 50% PAR number of leaves per plant did not decrease significantly in bottle gourd. Leaf weight ratio (LWR) remained more or less similar up to 50% reduction of PAR. SPAD value increased with the reduction of PAR level i.e. partial shading stimulated chlorophyll synthesis in leaves. Compared to 100% PAR the total dry matter did not reduce. Bottle gourd produced the highest yield (41.53 t ha^{1}) at 75% PAR level and it did not show significant fruit yield reduction at 25% PAR level compared to full sunlight. However, considering Total Dry Matter (TDM) and fruit yield of bottle gourd and cucumber were found suitable for reduced light condition (up to 50% PAR).

In order to improve the light composition in the solar greenhouse, Wang *et al.* (2007) supplied red, blue, UV-A and UV-B light, and the effects of the different light qualities on the growth characteristics of cucumber were investigated. When under UV-B light the stoma conduction, transpiration rate, and the CO_2 concentration between cells as well as the photosynthesis rate were decreased, at the same time the germination rate, fresh and dry weight, plant height and flower differentiation number were decreased; while the stoma density and thickness of cucumber leaf were increased greatly.

The possibility of intercropping cinnamon (*C. verum*) with rubber (*H. brasiliensis* clone RRIC 100) planted with the standard inter row spacing of 8.1 m was examined in Sri Lanka by Pathiratna and Perera (2005). PAR transmission from the rubber canopy into the middle of the inter row was reduced to 20.6% by the eighth year. Length per stick, weight and bark yield of cinnamon also declined. The reduction in bark yield of cinnamon per bush was 70.5% by the eighth year. The dry matter content of bark was highest (9.36%) when the light level was approximately 60%. Adverse effects of poor light availability and competition from rubber on cinnamon at this spacing by the fifth year were evident.

A study was conducted by Wang *et al*. (2003) to investigate illumination effect and its influence on the growth of some medicinal plants in an intercropping system with

Populus tomentosa at different row spacing. The daily average light intensity between rows decreased with decrease in row spacing. The height growth of *Glycyrrhiza uralensis*, *Platycodon grandiflorus* and *Pinellia pedatisecta* was different when intercropped with *Populus tomentosa*.

Field experiments were conducted by Shikata *et al*. (2003) in Japan in 1999 to analyse the effect of intercropping with maize on the growth and light environment of cowpea and to evaluate the canopy photosynthetic rate in relation to the leaf area index (LAI), light interception, and leaf net photosynthetic rate. Superior light interception obtained by intercropping with maize led to an increase of the LAI with a decrease of the light extinction coefficient and resulted in a high canopy photosynthetic rate.

In Nordic winter conditions with a shortage of natural light, it is very important to grow species and cultivars suited for low light and artificial lighting reported by Sevelius (2003). The present study was conducted to determine if leaf net CO_2 exchange, chlorophyll a fluorescence, oxygen evolution, chlorophyll a and b content, or leaf morphology would be useful in assessing gerbera (*Gerbera cantabrigensis*) growth in low light. Biomass accumulation as well as flower yield was lowest in Lynx.

A field experiment was conducted by Sharaiha and Battikhi (2002) in the summer season of 1999, at the Faculty of Agriculture Research Station, University of Mutah, South Jordan. Maize and potato yields were increased especially under the 2:2 intercropping row arrangements. The increase of potato yield might be related to the reduction in air heat units (by 210 and 28), soil heat units (by 80 and 88), and light interception (by 350 and 344 micro mol m^{-2} $second^{-1}$) for Frisia and Berca, respectively, compared to their sole crops. Moreover, the values of soil moisture storage and evapotranspiration for Frisia tended to decrease under intercropping compared to sole cropping.

Baumann *et al*. (2002) established an ecophysiological model was used to improve understanding of interplant competition based on physiological, morphological and phenological processes. Dry matter production of the species, particularly if grown in mixture, was highly sensitive to maximum plant height and radiation use efficiency.

Cucumber plants were grown by Peil and Lopez (2002) under greenhouse and shading screen-inducing conditions of diffuse light during summer in Southern Spain, with two intensities of fruit removal viz., one fruit remaining per leaf axil and two fruits remaining per three leaf axils. The effects of fruit removal on biomass production were greater in terms of vegetative rather than total fruit growth and of dry rather than fresh weight. Increasing fruit removal intensity increased dry matter allocation to the vegetative organs and the total aboveground dry matter production. Although dry matter production of the vegetative parts of the shoot strongly increased with increasing fruit removal intensity, the dry matter allocation between stems and leaves was not affected.

Light interception of a cucumber row crop was investigated by Peil *et al*., (2002) under greenhouse conditions during two growth periods (spring and summer). Measurements of the photosynthetic active radiation (PAR) were performed throughout the growth periods at the top (PARo) and at the bottom (PARt) of the crop. Shading screen-inducing conditions of diffuse light was used in summer, leading to a reduction of the integral of the incoming PAR (Sigma PARo) of 33% (1036 and 691 mol m^{-2} in spring and summer, respectively). To estimate the intercepted light by the crop, an existing model of canopy light interception (M_1) by a row crop was used along with a simple estimation approach based on the Lambert-Beer's law. Validation of the models was performed using experimental data, assuming that all PARo in summer was diffuse.

Intercropping provides an important means of raising not only productivity and land-use efficiency of smallholder rubber lands, but also income generation during the unproductive immature phase of the rubber tree reported by Rodrigo *et al*. (2001). Dry matter production in the rubber-based treatments was directly related to planting density, being least in the sole rubber and greatest in intercrop. Dry matter across treatments was derived from an increase not only in light capture (270%) but also radiation-use efficiency (RUE, 230%). Neither R nor BR treatment, which is currently recommended for intercropping in Sri Lanka, achieved full ground cover with fractional interception remaining below 40 and 50%, respectively. Fractional interception was greatest in BBBR treatment, and by the end of the measurement period, total intercepted radiation was 23 and 73% greater than that in the BBR and BR intercrops, respectively.

A field experiment was conducted by Roodagi, *et al*. (2001) in Karnataka, India, during 1997-98, to determine the effect of sowing methods and intercropping on leaf area index (LAI), light transmission ratio (LTR) and cane yield of sugarcane. Sowing methods consisted of normal sowing (ridge and furrow, 90 cm) and paired row methods (60-120-60 cm). The highest cane and sugar yields were in the cane+sunnhemp intercropping system, while the lowest were in cane+maize intercropping system

Gerbera jamesonii cv. Illusion, *Rosa hybrida* cv. Frisco, *Kalanchoe blossfeldiana* cv. Tenorio and *Ficus benjamina* cv. Exotica were grown under laboratory conditions by Buwalda *et al*. (2000) and exposed to 3 different patterns of temperature variation at 2 levels of average temperature (18 and 22^{0}C) and 2 light levels (2.5 and 5.5 mol PAR m^{-2} d^{-1}) over a growing period of 72 days. The experiments were carried out in 16 phytotrons of 15 m^2 each with light levels of 2.5 and 5.5 mol PAR m^{-2} d^{-1} and 4 temperature levels (14, 18, 22 and 26^{0}C). *F. benjamina* final fresh weight, shoot length and number of side shoots were superior at the higher light level.

Three experiments were conducted Bodson and Verhoyen (2000) between November and April during 1994-97 to investigate the effects of photoperiod, supplementary light intensity and daily supplementary light integral on gerbera (*Gerbera cantabrigensis* cultivars Estelle and Ximena) flowering in poor natural light conditions. The plants were subjected to different photoperiods (12, 18 and 24 h), light intensities (75, 112.5, 150 and 300 micro mol/m^2 s^{-1} PAR) and supplementary lighting periods (12, 18 and 24 h). In all experiments, the 12-h photoperiod produced the highest number of inflorescences if the same daily supplementary light integral was used. As the quantity of gerbera flower yield was strongly affected by supplementary lighting regimes, the grower must be aware of different distributions of the same light energy over one day, which may lead to a change of about 45% in number of inflorescences.

A greenhouse study was carried out by Labeke and Dambre (1999) in Belgium to investigate the effects of supplementary light on Gerbera cv. Tiffany (small flowers) and cv. Optima (large flowers). Gerbera was planted on 11 August 1998 on rockwool mats (6/m^2 for cv. Tiffany and 4/m^2 for cv. Optima). Supplementary light (approx.

3000 lux) was used when natural light reached 150 W/m^2. Data were collected weekly on the number of flowers/plant, stem length, weight and diameter of flowers. Supplementary light increased the number of flowers/m^2 of cv. Optima significantly (by Supplementary light increased flower production in cv. Tiffany slightly (by 6%). However, significant increases were measured for flower diameter (between October and December), stem length (between December and April), and stem weight (between October and May).

A field experiment was conducted by Ahmed and Jahan (1998) during rabi season 1992-93, in Gazipur, Bangladesh to evaluate the effect of intercropping wheat (cv. Sonalika) with potato (cv. Cardinal) on light interception, leaf area index and dry matter production. The treatments comprised 100% potato + 100% wheat in 1 or 2 rows, 100% potato + 50% wheat in 1 or 2 rows, and 100% potato + 25% wheat in 1 or 2 rows. Leaf area index (LAI) and dry matter production by the component crops were reduced due to intercropping.

In many crop models, light intercepted by a canopy (IPAR) is calculated by Flenet *et al*. (1996) from a Beer's Law equation: IPAR = PAR × (1 - exp(-K × LAI)), where k is the extinction coefficient, PAR the photosynthetically active radiation, and LAI the leaf area index. The effect of row spacing on k was investigated for maize, sorghum, soyabeans and sunflowers to provide information for modelling. It is recommended that modelling light interception for different row spacings should account for these effects.

2.2 Effect of fertilizer management

Field experiments were conducted by Singh *et al*. (2004) on a Mollisol in Pantnagar, Uttaranchal, India, to determine the effects of integrated nutrient management on crop nutrient uptake and yield under okra pea tomato cropping sequence. In the sequence, treatments were given to okra crop, while in the succeeding crops (pea and tomato), only recommended dose of fertilizers were applied on the basis of soil test. The treatments consisted of UreaTSPMP recommended dose of 80:30:30 kg/ha (T_1); farmyard manure (FYM) at 15 tones/ha + rest of the UreaTSPMP (T_2); neem cake at 3 q/ha + rest of the UreaTSPMP (T_3); poultry manure at 3 tonnes/ha + rest of the UreaTSPMP (T_4); Azospirillum + 75% Urea + recommended dose of TSP and MP (T_5); vesicular arbuscular mycorrhizas (VAM) + 50% TSP + recommended dose of Urea and MP (T_6); phosphate solubilizing bacteria (PSB) + 75% TSP + recommended Urea and MP (T_7); Azospirillum + VAM + PSB + rest of the UreaTSPMP (T_8); micronutrient+recommended dose of UreaTSPMP (T_9); FYM + Azospirillum + VAM + PSB + rest of the UreaTSPMP (T_{10}); and recommended dose of UreaTSPMP + pea straw incorporation in the soil before tomato planting (T_{11}). In the case of okra and pea crops, only the recommended dose of UreaTSPMP was given in T_{11}. The treatments were applied in the first crop and their effect was observed on instant as well as succeeding crops. The integrated use of organic and inorganic sources of nutrients and biofertilizers increased the Urea, TSP and MP concentrations in the plants (including fruits) of tomato. The integrated nutrient management also significantly increased shoot dry matter yield of tomato and fruit yields of tomato.

An experiment was conducted by Chapagain *et al*. (2003) to find out the effects of potassium chloride (KCl) as a potassium (K) source in fertilization solution on growth, yield and quality of tomato (cv. Durinta) in a controlled greenhouse were compared with potassium nitrate (KNO_3) - the conventional K source for vegetable fertilization. The treatments consisted of four levels of KCl: (1) 0% KCl (100% KNO_3), (2) 40% KCl (40% KCl and 60% KNO_3), (3) 60% KCl (60% KCl and 40% KNO_3), and (4) 100% KCl (0% KNO_3) in fertilization solution in the season 1999-2000. In 2000-2001, early (12 days after planting) and late (47 days after planting) applications of 100% KCl and 0% KCl were tested. The concentrations of K and other major nutrients were similar in all the treatments. Ammonium nitrate (NH_4NO_3), calcium nitrate [$Ca(NO_3)_2$] and nitric acid (HNO_3) were used as nitrogen (N) sources in KCl treatments. Plant height, time to anthesis, time to harvest, and leaf nutrient content were monitored. No significant differences in yield components and plant growth were recorded among the treatments. It was concluded that KNO_3 can be replaced fully or partially (depending on water quality) by KCl in tomato production while improving the quality of fruits.

Results are given of several studies in different regions by Johnston *et al*. (2003) in Iran on the effects of different rates of K fertilizer application on crop yield and water use efficiency. All the soils used in these experiments were calcareous soils. On farms growing wheat in the Karaj and Darab regions, different rates and sources of K were tested in 1999. Some 3120 and 3900 m^3 water/ha were used in Karaj and Darab, respectively. In a tomato plantation in Marand region, muriate of potash at 2 rates (100 and 150 kg K_2O/ha) with 8000 m^3/ha of irrigation water was tested in 1999 and found that 150 kg K_2O/ha superior than 100 kg K_2O/ha regarding yield and yield contributing characters.

The study on the effect of organic and inorganic fertilizers on yield and quality of tomato (cv. Parbhani "Yashashri") conducted in Parbhani, Maharashtra, India, by

Mohd *et al*. (2002) to 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. The study also revealed that the ready made organic manures of commercial companies used in this study were inferior to traditional organic manures, viz. FYM and vermicompost.

The placement of urea briquettes (UB) at 3-4 cm depth was found better than surface application by Kadam (2001). UB increased grain yield of rice over split applied urea by 0.23-1.48 t/ha (5-83%). It was possible to deep place UB mechanically and achieves the agronomic efficiency that was obtained by hand placement of UB. The deep placement of urea-diammonium phosphate (DAP) briquette (one U-DAP/4 hills) increased grain yield of rice by 11-86% and straw yield by 9-62% over single superphosphate and prilled urea. The application of NPK fertilizer briquette to tomato increased the number of fruits.

Two field experiments were conducted in Egypt by Awad *et al*. (2001) to study the effect of intercropping parsley and demsisa with tomato under 4 rates of N fertilizer (100, 120, 140 and 160 kg N/fed). The results showed that increasing N fertilizer rate enhanced total yield and net assimilation rate (NAR) of both mono and mixed crops, earliness index of tomato and UreaTSPMP uptake of tomato in NAR, total yield, earliness index and Urea uptake. The best values were obtained by pure stand planting at the highest Urea rate (160 kg N/fed), whereas the best TSP and MP uptake were attained at 140 and 120 kg N/fed, respectively. The highest value of Urea supplementation index (NSI) for tomato was obtained at 100 kg N/fed, whereas the highest values of phosphorus supplementation index (PSI) and potassium supplementation index (KSI) were recorded by plants which received 160 kg N/fed.

Tomato cv. House Momotaro plants growing in perlite with a nutrient solution were supplemented with 10, 20, 30 or 40 mM KCl or NaCl on various dates after anthesis, to determine the optimum salt concentration and application time for the improvement of fruit quality in tomatoes by Rhee *et al*. (2001). The number of fruit binds was limited to 2 and planting density was increased to minimize yield loss. Fruit quality improved as the salt concentration increased and improved with earlier applications. However, the improvements were accompanied by proportional yield reductions. KCl at 20 mM and NaCl at 25 mM improved fruit quality without significantly reducing yield. Application 20 days after anthesis of the first truss flowers gave the best results.

A long-term field experiment was conducted by Wijewardena and Amarasiri (1997) at Bandarawela (Sri Lanka) on a Red Yellow Podzolic soil during the ten cropping seasons commencing Maha 1986/87. Four levels of potassium fertilizers at rates of 0, 25, 50 and 100 kg K_2O/ha were applied for each crop. Potato, cabbage, tomato, pole bean, cabbage, potato, cabbage, tomato, pole bean and cabbage were cultivated in this sequence. After cultivation of low K removal crops such as potato and pole bean, soil exchangeable K increased when 100 kg K_2O/ha was applied. Soil K increased when potassium was continuously applied to soil at 100 kg K_2O/ha but the cropping sequence was an important factor to be considered. High yields of vegetables e.g. tomato could be obtained with 100 kg K_2O/ha per season without any accumulation of K in the soil.

An experiment was conducted by Song and Fujiyama (1996) in a hydroponically grown tomato cv. 'Saturn' plants subjected to Na-salinization (addition of 80 mmol Na/kg) was given 0-50 mmol K/kg. Addition of 10 mmol K increased growth by decreasing the content of Na and increasing the K content of the plants. Higher K concentrations decreased growth compared with the optimum rate, such that plant DW at the highest K rate was similar to that with 80 mmol Na alone. Growth of both species was best in control (unsalinized) plants. Total cation content increased with increasing K concentration, due to increased plant K content. A close relationship was observed among the osmotic potential of the solution, cumulative transpiration, and dry weight for both species among the K treatments. Addition of K suppressed the uptake of other cations by tomatoes in the order of Na > Mg\more than\Ca, with a very small suppression for Ca and Mg.

An experiment was undertaken by Martin and Liebhardt (1994) to determine if a high K-requiring crop such as tomato (cv. Redpak) would respond to KCl fertilizer rate or lime type (dolomitic, calcitic and mixed) and rate on such a soil. K was applied at 0, 56 or 112 kg/ha every year for 10 years. Lime was applied at 0, 2 or 9 t/ha in calcitic, mixed and dolomitic forms twice in 10 years. In 1980, the tenth year of the study, tomato fruits were harvested by hand once-over to simulate machine harvesting and divided into 4 maturity groups by colour. Soil pH was higher with dolomitic than calcitic lime. Soil K saturation was not influenced by lime rate or type. Fruit yield and leaf P, Ca and Mg increased with increasing lime rate. Lime type had no effect on tomato yield. Wide ranges in basic cation saturation ratios had little effect on yield. Soil K saturation and leaf K, Zn and Ba concn increased with increasing K rate. Soil Ca and leaf Ca and Mg decreased with increasing K rate. Applied K had no effect on total yield but once-over marketable yield increased linearly with increasing K rate. Marketable yield increased by 14% with an increase in K rate from 0 to 56 kg/ha.

In field experiments on red sandy loam soil was conducted by Rao (1994) to find out the effects of K at 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. In carrot, mean root weight and yield were highest at 50 kg K_2O/ha. Carotene content was increased by K application. In cauliflower, the mean curd weight, compactness of the curd and yield were highest at 150 kg K_2O/ha as KCl.

Tomato cv. 'Hisar Arun' and okra cv. 'Pusa Sawani' were planted during the 1991-92 and 1992-93 seasons at Haryana Agricultural University as a crop after potato by Taya *et al*. (1994). The preceding potato crop received either the recommended fertilizer regime of 150 kg N/ha, 50 kg P_2O_5/ha and 100 kg K_2O/ha (F1) or 33% higher than recommended rates (F_2), with (Z_1) and without (Z_0) 25 kg/ha $ZnSO_4$. The subsequent crops received either N fertilizer at 0 (N_0), 25 (N_1), 50 (N_2) and 75% (N_3) of the recommended rate or 100 kg N/ha, 50 kg P_2O_5/ha and 50 kg K_2O/ha (UreaTSPMP). The F_1 and Z_1 treatments increased plant height at 90 days after planting, fruit number and yield in the subsequent crops of tomato and okra; the F1 treatment also increased the UreaTSPMP content of foliage, and delayed flowering in both crops. With the tomato crop, there were no significant differences in fruit number and yield between N_2, N_3 and UreaTSPMP treatments in both seasons.

A fertilizer trail was conducted by Pansare *et al*. (1994) to find out the effect of different Urea, TSP and MP on yield and quality of tomato. They found that the maximum yield of high quality tomatoes was obtained when straight fertilizers were added in the Urea, TSP, MP ratio of 3: 1: 2 (150 kg N/ha, 50 kg P_2O_5/ha, 100 kg K_2O/ha).

Cerne and Briski (1993) conducted field trials on the fertilizer and irrigation requirement of tomato cv. 'Rutgers' plants where 250 kg N and 72 kg P_2O_5/ha plants 200 or 400 kg K_2O/ha in the first year, 0 or 200 kg K_2O/ha in the second year, 0 or 40 t ; stable manure/ha were applied in all treatments. The combination of 400 kg K_2O/ha stable manure and irrigation gave the highest total yield in the 1st and 2nd years (1.03 and 2.25 kg/plant, respectively).

Mehlich-I soil-test calibrations and fertilizer recommendations were reviewed in relation to the current literature by Hanlon and Hochmuth (1992). This review led to 22 research/demonstration experiments conducted predominantly on cooperators' fields, with 5 crop species. Soils selected for these trials included Ultisols, Spodosols, and Entisols. Minimum data collection at all sites included preplanting soil tests (0- to 15-cm depth) using the Mehlich-I extractant, leaf tissue sampling and harvest data using USDA grading standards. Typically, 4 or 5 rates of TSP and/or MP were used with 4 or 5 replications. Extensive changes were also made in fertilizer recommendations for Urea, TSP and MP vegetable production, including a recommendation for no fertilizer TSP and MP when the Mehlich-I soil test is interpreted as high or very high.

Silva and Vizzotto (1990) conducted field trail with the cultivar Angela Gigante 1-5, 100, the plants received N: P_2O_5: K_2O at 30-180; 75-450: 30-180 kg/ha plus poultry manure at 0, 10 or 20 t/ha. The largest fruits and the highest yields (53 t/ha) were obtained by applying N: P_2O_5: K_2O at 104: 259: 140 kg/ha plus poultry manure at 20 t/ha.

Cholakov and Rankov (1988) studied the nutrient uptake by determinate tomato cultivars. They found that the amounts of nutrient taken by crops producing 75.5 to 37.5 t/ha from 205.8 to 235.7 kg for Urea, 68.5 to 77.0 kg for P_2O_5 and 248.3 to 315.9 kg |for K_2O/ha. Cultivar 'Stava' showed the highest TSP and MP uptake and 'Marti' the highest Urea uptake. The average amounts of nutrient required to produce 1 ton of tomato fruit were 2.72 kg N, 0.88 kg P_2O_5 and 3.51 kg K_2O.

Mehta and Saini (1986) conducted, two year fertilizer trails and found the plants received basal FYM (20 t/ha) and Urea at 75-125, P_2O_5 at 60-90 or K_2O at 30-60 kg/ha, significant yield increases were obtained with the highest Urea and MP rates.

Ahmed and Saha (1986) studied the effect of different levels of Urea, TSP and MP as the growth and yield of four tomato varieties. They apply Urea at 35, 65 or 85 kg/ha, P_2O_5 at 65, 95 or 115 kg/ha and K_2O at 25, 35 or 45 kg/ha to the four cultivars. Significant differences were recorded for different level of fertilizer for different tomato varieties. All cultivars gave the highest yield at the highest UreaTSPMP rates namely, 44.78-52.0, 41.78-46.67, If 35.55-41.0 and 31.88-36.33 t/ha in 'Bikash', 'Tushti', 'Roma VF' and 'Asha-4', respectively.

Barooh and Ahmed (1983) conducted a fertilizer experiment to study the effect of UreaTSPMP fertilizers on growth, development and yield of tomato. They reported that UreaTSPMP fertilizer significantly affects the growth and yield of tomato and the highest net profit was obtained with UreaTSPMP at 120:120:60 kg/ha.

Belichki (1983) conducted an experiment to investigate fertilization of the tomato cultivar 'Triumph' grown for early field production. He reported that highest yields of good quality fruits were produced with 240 kg N: 103.2 kg P: 99 kg K/ha for the tomato cultivar 'Triumph'.

Gupta *et al.* (1978) observed the effect of UreaTSPMP on plant height, earliness, fruit size, TSS and acidity contents. They found that tomato cvs H.S.101 and Sioun responded best in respect of yield to 75 kg N/ha and the cv. Pusa Ruby to 150 kg N/ha. All three cultivars responded to 60 kg $P2O_5$ compared with nil P (control) but in the case of K: only Pusa Ruby responded to 60 kg K_2O/ha; in the other two cvs, the yield was depressed by the application of K.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from April to October 2011. The materials and methods that were used and followed for conducting the experiment presented under the following headings-

3.1 Experimental site

The study was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the effect of light intensity and fertilizer management on growth and yield of summer tomato. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under 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 were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics were presented in Appendix I.

3.3 Climatic condition of the experimental site

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

Seedlings of 30 days of BARI Tomato-4 were used. The seedlings of tomato were grown at the nursery of Horticultural Farm in Sher-e-Bangla Agricultural University.

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Light intensity (three levels) as

- i L_1: 50% PAR (Photo-synthetically Active Radiation)
- ii. L_2: 75% PAR (Photo-synthetically Active Radiation)
- iv. L_3: 100 PAR (Photo-synthetically Active Radiation)

Factor B: Fertilizer management (four levels) as

- i. F_0: Control (No fertilizer application)
- ii. F_1: $Urea_{300\ kg/ha}$ + $TSP_{200\ kg/ha}$ + $MP_{150\ kg/ha}$
- iii. F_2: $Urea_{350\ kg/ha}$ + $TSP_{250\ kg/ha}$ + $MP_{180\ kg/ha}$
- iv. F_3: $Urea_{400\ kg/ha}$ + $TSP_{300\ kg/ha}$ + $MP_{210\ kg/ha}$

There were 12 (3 × 4) treatments combination such as F_0L_1, F_0L_2, F_0L_3, F_1L_1, F_1L_2, F_1L_3, F_2L_1, F_2L_2, F_2L_3, F_3L_1, F_3L_2 and F_3L_3.

3.6 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 135.32 m^2 with length 19.9 m and width 6.8 m. The total area was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.5 m × 2.4 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Plants were transplanted in the plot with maintaining distance between row to row and plant to plant was 60 cm and 50 cm, respectively. The layout of the experiment is shown in Figure 1.

3.7 Raising of seedlings

Tomato seedlings were raised in three seedbeds of 3 m × 1 m 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. Ten gram of seeds was sown on each seedbed on April 2011. After sowing, seeds were covered with light soil. Heptachlor 40 WP was applied @ 4 kg/ha, around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place with 5 to 6 days after sowing. Weeding, mulching, irrigation, drainage and shading were done as and when required.

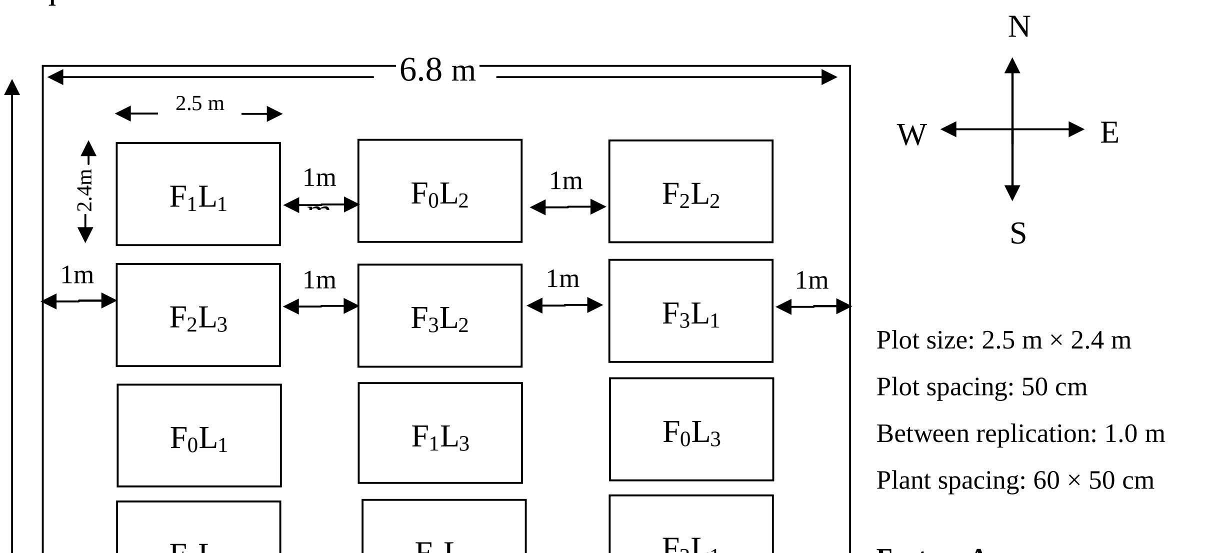

Figure 1. Layout of the experimental plot

3.8 Land preparation

The plot selected for conducting the experiment was opened in the last week of April 2011 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 until good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for transplanting tomato seedlings. The experimental plot was partitioned into unit plots in accordance with the design mentioned in Figure 1.

3.9 Application of manure and fertilizers

Well decomposed cow dung @ 10 t/ha were applied during final land preparation and all of the chemical fertilizers were applied as per 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 04 June, 2011 maintaining a spacing of 60 cm × 50 cm between the rows and plants, respectively. This allowed an accommodation of 20 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 hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.11 Transplanting of seedling and treatments establishment

The tomato plants received full natural radiation without any barrier that constituted the 100% light level. The reduced light intensity of 75% and 50%, respectively were created by using nylon nets as compared to open field light (100% PAR) Single color of white color mosquito net was used to create 75% PAR, Single ply of blue colored mosquito net was used to create 50% PAR. The light levels were obtained by adjusting mesh size, number of color Sunflec Septometer (Accu PAR Version2.1.) was used to have the desired light intensity along with net quality.

When crop establishment were completed the nylon nets were hanged from six feet over with the support of bamboo pillars. No net was used in the 100% PAR level plot. After setting the nets, light (PAR) measured again outside and inside the nets to check the PAR calibration.

3.12 Intercultural operation

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

3.12.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after transplanting seedlings in every alternate day in the evening upto seedling establishment. Further irrigation was provided when needed. Excess water was effectively drained out at the time of heavy rain.

3.12.2 Sticking

When the plants were well established, staking was given to each plant by Dhaincha (*Sesbania* sp.) sticks to keep them erect within a few days of staking, as the plants grew up.

3.12.3 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. Mulching for breaking the crust of the soil was done when needed.

3.12.4 Top dressing

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. Eathing up operation was done immediately after top-dressing with nitrogen fertilizer.

3.13 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 for a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide. During foggy weather precautionary measured against disease infection 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.

3.14 Harvesting

Fruits were harvested at 3 days interval during early ripe stage when they attained slightly red color. Harvesting was started from September, 2011 and was continued up to October 2011.

3.15 Data collection

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

3.15.1 Plant height

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

3.15.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAT to 60 DAT at 10 days interval.

3.15.3 Number of branches per plant

The total number of branches per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 20 DAT to 60 DAT at 10 days interval.

3.15.4 Days required for transplanting to 1st flowering

Days required for transplanting to initiation of flowering was counted from the date of transplanting to the initiation of flowering and was recorded.

3.15.5 Days required for transplanting to 1st harvesting

Days required for transplanting to 1st harvesting was counted from the date of transplanting to the harvesting of fruits at first time and was recorded.

3.15.6 Number of flower cluster per plant

The number of flower cluster was counted from the sample plants and the average numbers of flower clusters produced per plant were recorded.

3.15.7 Number of flowers per cluster

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

3.15.8 Number of flowers per plant

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

1.15.9 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.

3.15.10 Number of fruits per plant

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

3.15.11 Length of fruit

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 selected marketable fruits from each plot and there average was taken and expressed in cm.

3.15.12 Diameter of fruit

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

3.15.13 Dry matter of plant

After harvesting, 150 g plant sample previously sliced into very thin pieces were put into envelop and placed in oven maintained at 70^0C 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:

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

3.15.14 Dry matter of fruit

After harvesting, randomly selected 150 g fruit 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 fruit were computed by simple calculation from the weight recorded by the following formula

$$\% \text{ Dry matter content of fruit} = \frac{\text{Dry weight of fruit}}{\text{Fresh weight of fruit}} \times 100$$

3.15.15 Weight of individual fruit

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

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

3.15.16 Yield per plant

Yield of tomato per plant was recorded as the whole fruit per plant and was expressed in kilogram.

3.15.17 Yield per hectare

Yield per hectare of tomato fruits was calculated by converting the weight of plot yield into hectare and was expressed in ton.

Measure of Light Intensity (LUX)

Light intensity was measured by light intensity meter in a 15 days interval.

3.16 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for fertilizer management and light intensity on yield and yield contributing characters of tomato. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.16 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of fertilizer management and light intensity. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 13% in simple rate. The market price of tomato was considered for estimating the cost and return. Analyses were done according to the procedure of Alam *et al.* (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to find out the effect of light intensity and fertilizer management on the growth and yield of tomato. Data on different growth parameters and yield of tomato was recorded and the analyses of variance (ANOVA) of the data are presented in Appendix III-VII. The results have been presented and discussed, and possible interpretations are given under the following headings:

4.1 Plant height

Different fertilizer management showed significant variation for Plant height of tomato at 20, 30, 40, 50 and 60 DAT (Figure 2). At 20 DAT, the longest plant (26.39 cm) was observed from F_2 which was statistically similar (25.89 cm) with F_3 and followed (23.23 cm) by F_1, whereas the shortest plant (19.56 cm) from F_0. At 30 DAT, the longest plant was observed from F_2 (38.14 cm) which was statistically identical with F_3 (36.57 cm) and followed by F_1 (34.59 cm), while the shortest from F_0 (29.63 cm). At 40 DAT, the longest plant was obtained from F_2 (53.18 cm) which was statistically similar with F_3 (51.44 cm) and F_1 (49.84 cm), again the shortest from F_0 (44.02 cm). At 50 DAT, the longest plant was found from F_2 (70.19 cm) which was similar with F_3 (69.57 cm) and F_1 (66.22 cm) and the shortest from F_0 (59.29 cm). At 60 DAT, the longest plant was found from F_2 (84.70 cm) which was statistically identical with F_3 (84.31 cm), while the shortest from F_0 (67.05 cm).Silva and Vizzotto (1990) recorded longest plant by applying N :P_2 0_5:K20at 104:259:140 kg/ha.

Plant height of tomato showed statistically significant variation for different levels of light intensity at 20, 30, 40, 50 and 60 DAT (Figure 3). The longest plant (26.11 cm, 36.61 cm, 52.81 cm, 70.02 cm and 84.29 cm) was obtained from L_3 which was statistically similar (25.48 cm, 35.53 cm, 51.56 cm, 68.21 cm and 80.25 cm) with L_2. Again, the shortest plant (21.77 cm, 31.95 cm, 44.47 cm, 60.71 cm and 70.94 cm) was recorded from L_1 at 20, 30, 40, 50 and 60 DAT, respectively.

Interaction effect of fertilizer management and light intensity showed significant variation in terms of plant height of tomato at 20, 30, 40, 50 and 60 DAT (Table 2). The longest plant (31.52 cm, 42.03 cm, 58.86 cm, 76.30 cm and 96.97 cm) was found from F_2L_2, while the shortest plant (18.61 cm, 28.53 cm, 42.95 cm, 57.60 cm and 65.11 cm) was recorded from F_0L_1 for 20, 30, 40 , 50 and 60 DAT

It was observed that F_2L_2 ($_{\text{Urea350 kg/ha}}$ + $_{\text{TSP250 kg/ha}}$ + $_{\text{MP180 kg/ha}}$) with 75% PAR ensured optimum vegetative growth and the ultimate results was the tallest plant but excess amount of fertilizer hindered plant growth but 100 PAR increase the plant height of Tomato.

Table 2. Interaction effect of fertilizer management and light intensity on plant height at different days after planting (DAT) of tomato

Treatments	Plant height (cm) at				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
F_0L_1	19.61 e	28.53 e	42.95 c	57.60 d	65.11 e
F_0L_2	20.06 e	29.61 e	44.11 c	59.47 d	66.10 e
F_0L_3	22.15 de	30.84 e	45.08 c	60.88 d	69.28 e
F_1L_1	21.34 de	31.00 e	43.94 c	60.42 d	71.87 de
F_1L_2	24.75 cd	35.85 cd	51.87 ab	68.31 bc	79.20 cd
F_1L_3	26.61 bc	36.88 bc	53.71 a	70.00 abc	82.87 bc
F_2L_1	20.59 e	31.86 de	43.33 c	59.70 d	65.12 e
F_2L_2	31.52 ab	42.03 ab	58.86 a	76.27 ab	96.94 ab
F_2L_3	30.02 a	39.01 a	56.12 a	73.24 a	95.21 a
F_3L_1	25.16 cd	35.50 cd	46.58 bc	63.28 cd	81.00 cd
F_3L_2	27.32 bc	37.14 bc	54.16 a	72.42 ab	83.78 bc
F_3L_3	28.18 abc	37.11 bc	53.60 a	73.06 ab	88.17 abc
$LSD_{(0.05)}$	3.579	4.042	6.340	6.643	9.066
Level of significance	0.01	0.05	0.05	0.05	0.01
CV(%)	8.52	6.87	7.54	5.91	6.82

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

F_0: Control (No fertilizer application)

F_1: Urea300 kg/ha + TSP200 kg/ha + MP150 kg/ha

F_2: Urea350 kg/ha + TSP250 kg/ha + MP180 kg/ha

F_3: Urea400 kg/ha + TSP300 kg/ha + MP210 kg/ha

L_1: 50% PAR

L_2: 75% PAR

L_3: 100% PAR

4.2 Number of leaves per plant

Number of leaves per plant of tomato showed statistically significant variation for different levels of fertilizer management at 20, 30, 40, 50 and 60 DAT (Figure 4). At 20 DAT, the maximum number of leaves per plant (6.59) was found from F_2 which was statistically identical (6.41 and 6.39) with F_3 and by F_1, whereas the minimum number (4.77) from F_0 (no fertilizer). At 30 DAT, the maximum number of leaves per plant was recorded from F_2 (16.50) which was statistically similar with F_3 (16.42) and F_1 (16.01), while the minimum number from F_0 (13.85). At 40 DAT, the maximum number of leaves per plant was observed from F_2 (28.93) which was statistically similar with F_3 (29.11) and closely followed by F_1 (27.37), again the minimum number from F_0 (24.47). At 50 DAT, the maximum number of leaves per plant was obtained from F_2 (36.62) which was identical with F_3 (36.49) and closely followed by F_1 (34.54), whereas the minimum number from F_0 (29.63). At 60 DAT, the maximum number of leaves per plant was recorded from F_2 (50.33) which was statistically identical with F_3 (47.67) and F_1 (46.44), while the minimum number from F_0 (40.16). It was observed that F_3 fertilizer ensured optimum vegetative growth with maximum number of leaves per plant. Optimum combination of fertilize ensured proper growth of plant that leads to highest number of leaves. Pena et al., 1988 reported similar results.

Different levels of light intensity varied significantly for number of leaves per plant of tomato at 20, 30, 40, 50 and 60 DAT (Figure 5). At 20 DAT, the maximum number of leaves per plant (6.43) was recorded from L_3 which was statistically identical (6.21) with L_2 again, the minimum number (5.53) from L_1. At 30 DAT, the maximum number of leaves per plant was recorded from L_3 (16.60) which were statistically identical with L_2 (16.23) again, the minimum number from L_1 (14.26). At 40 DAT, the maximum number of leaves per plant was recorded from L_3 (28.83) which were statistically similar with L_2 (28.33) whereas the minimum number was observed from L_1 (25.25). At 50 DAT, the maximum number of leaves per plant was found from L_3 (35.85) which were closely followed by L_2 (34.41) while, the minimum number from L_1 (32.71). At 60 DAT, the maximum number of leaves per plant was recorded from L_3 (52.16) which were statistically identical with L_2 (48.67) again, the minimum number from L_1 (37.62). Haque et al(2009) found that number of leaves per plant decreased due to the reduced light levels.

Number of leaves per plant at 20, 30, 40, 50 and 60 DAT showed significant variation due to the interaction effect of fertilizer management and light intensity (Table 3). The maximum number of leaves per plant (7.29, 17.97, 31.07, 39.37 and 61.33) was observed from F_2L_3. On the other hand, the minimum number of leaves per plant (4.71, 13.54, 23.81 and 28.93) was recorded from F_0L_1 (no fertilizer and 50% PAR) for 20, 30, 40 and 50 DAT, respectively while at 60 DAT the minimum number of leaves per plant (32.29) was found from F_2L_1.

Table 3. Interaction effect of fertilizer management and light intensity on number of leaves per plant at different days after planting (DAT) of tomato

Treatments	Number of leaves per plant at				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
F_0L_1	4.73 f	13.60 b	23.87 c	28.97 g	39.82 ef
F_0L_2	4.77 f	13.83 b	24.60 c	29.57 g	38.67 ef
F_0L_3	4.90 ef	14.13 b	24.93 c	30.37 fg	41.99 de
F_1L_1	5.73 d	14.20 b	25.00 c	33.20 de	35.33 ef
F_1L_2	6.60 abc	16.73 a	28.27 ab	34.57 cde	50.00 bcd
F_1L_3	6.87 abc	17.13 a	28.83 ab	35.87 bc	54.00 abc
F_2L_1	5.50 de	13.90 b	25.10 c	32.53 ef	32.33 f
F_2L_2	7.03 ab	17.67 a	30.63 a	37.97 ab	57.33 ab
F_2L_3	7.30 a	17.97 a	31.07 a	39.37 a	61.33 a
F_3L_1	6.13 cd	15.10 b	26.30 bc	35.53 bcd	43.00 de
F_3L_2	6.47 bc	16.93 a	30.57 a	36.13 bc	48.67 cd
F_3L_3	6.73 abc	17.17 a	30.47 a	37.80 ab	51.33 bc
$LSD_{(0.05)}$	0.6857	1.628	2.538	2.432	7.683
Level of significance	0.05	0.05	0.05	0.01	0.01
CV(%)	6.67	9.12	5.46	11.18	9.83

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

F_0: Control (No fertilizer application)

F_1: Urea300 kg/ha + TSP200 kg/ha + MP150 kg/ha

F_2: Urea350 kg/ha + TSP250 kg/ha + MP180 kg/ha

F_3: Urea400 kg/ha + TSP300 kg/ha + MP210 kg/ha

L_1: 50% PAR

L_2: 75% PAR

L_3: 100% PAR

4.3 Number of branches per plant

Different fertilizer management differed significantly for number of branches per plant of tomato at 20, 30, 40, 50 and 60 DAT due to the (Figure 6). At 20 DAT, the maximum number of branches per plant (5.35) was recorded from F_2 which was statistically identical (5.23 and 5.06) with F_3 and by F_1, while the minimum number (4.42) from F_0 (no fertilizer). At 30 DAT, the maximum number of branches per plant was obtained from F_3 (8.14) which was statistically identical with F_2 (8.09) and closely followed by F_1 (7.27), while the minimum number from F_0 (6.51). At 40 DAT, the maximum number of branches per plant was obtained from F_3 (12.81) which was statistically identical with F_2 (12.59) and followed by F_1 (11.36), whereas the minimum number from F_0 (9.76). At 50 DAT, the maximum number of branches per plant was found from F_2 (18.53) which was identical with F_3 (17.88) and followed by F_1 (16.74), again the minimum number from F_0 (13.02). At 60 DAT, the maximum number of branches per plant was found from F_3 (23.37) which was statistically identical with F_2 (23.21) and F_1 (21.90), while the minimum number from F_0 (18.46).

Significant variation was observed at 20, 30, 40, 50 and 60 DAT for number of branches per plant of tomato for light intensity (Figure 7). At 20 DAT, the maximum number of branches per plant (5.67) was attained from L_3 which was statistically identical (5.39) with L_2 and the minimum number (3.98) was observed from L_1. At 30 DAT, the maximum number of branches per plant was recorded from L_3 (8.31) which were statistically identical with L_2 (7.97) again, the

minimum number from L_1 (6.23). At 40 DAT, the maximum number of branches per plant was found from L_3 (12.49) which were closely followed by L_2 (11.69) while the minimum number was observed from L_1 (10.70). At 50 DAT, the maximum number of branches per plant was recorded from L_3 (17.59) which were statistically similar with L_2 (16.82) whereas, the minimum number was observed from L_1 (15.22). At 60 DAT, the maximum number of branches per plant was observed from L_3 (23.62) which were closely followed by L_2 (22.20) again, the minimum number from L_1 (19.38).

Significant variation was recorded for the interaction of fertilizer management and light intensity in terms of number of branches per plant at 20, 30, 40, 50 and 60 DAT (Table 4). The maximum number of branches per plant (6.50, 9.42, 13.85, 20.45 and 26.13) was observed from F_2L_3 whereas the minimum (4.22, 6.12, 9.14, 12.44 and 17.33) was recorded from F_0L_1 for 20, 30, 40, 50 and 60 DAT, respectively. It was revealed that F_2L_3 fertilizer ensured optimum vegetative growth with maximum number of branches per plant.

4.4 Days required for transplanting to 1st flowering

Days required for transplanting to 1st flowering of tomato varied significantly for different fertilizer management (Table 5). The highest days from transplanting to 1st flowering (32.40) was recorded from F_3 which was statistically identical (32.33 and 30.47) with F_0 (no fertilizer) and F_1, respectively. On the other hand, the lowest days (28.67) was recorded from F_2.Tara et al.(1994) reported that NPK in higher content of foliage delayed flowering of tomato.

Table 4. Interaction effect of fertilizer management and light intensity on number of branches per plant at different days after planting (DAT) of tomato

Treatments	Number of branches per plant at				
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
F_0L_1	4.22 c	6.12 e	9.14 d	12.44 g	17.33 d
F_0L_2	4.45 c	6.64 de	9.76 cd	13.01 g	18.90 d
F_0L_3	4.59 c	6.77 de	10.38 cd	13.61 fg	19.13 d
F_1L_1	3.95 cd	6.19 e	10.42 cd	15.18 ef	19.67 cd
F_1L_2	5.46 b	7.59 cd	11.34 bc	17.13 cde	22.20 bc
F_1L_3	5.76 ab	8.02 bc	12.34 ab	17.90 bc	23.83 ab
F_2L_1	3.31 d	5.72 e	10.17 cd	15.40 def	18.83 d
F_2L_2	6.23 ab	9.12 a	13.73 a	19.73 ab	24.67 ab
F_2L_3	6.49 a	9.43 a	13.86 a	20.45 a	26.13 a
F_3L_1	4.20 c	6.36 e	12.46 ab	17.27 cd	20.13 cd
F_3L_2	5.64 ab	9.04 ab	12.56 ab	17.98 bc	24.60 ab
F_3L_3	5.84 ab	9.03 ab	13.39 a	18.39 bc	25.37 a
$LSD_{(0.05)}$	0.8138	0.9946	0.5193	1.914	2.796
Level of significance	0.01	0.01	0.05	0.05	0.01
CV(%)	9.59	7.83	7.73	6.83	7.60

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

F_0: Control (No fertilizer application)

F_1: $_{\text{Urea300 kg/ha}}$ + $_{\text{TSP200 kg/ha}}$ + $_{\text{MP150 kg/ha}}$

F_2: $_{\text{Urea350 kg/ha}}$ + $_{\text{TSP250 kg/ha}}$ + $_{\text{MP180 kg/ha}}$

F_3: $_{\text{Urea400 kg/ha}}$ + $_{\text{TSP300 kg/ha}}$ + $_{\text{MP210 kg/ha}}$

L_1: 50% PAR

L_2: 75% PAR

L_3: 100% PAR

light intensity showed statistically significant differences in terms of days required for transplanting to 1st flowering of tomato (Table 5). The highest days from transplanting to 1st flowering (31.90) was recorded from L_1 which was statistically identical (31.30) with L_3 again, the lowest days (29.70) was recorded from L_2.

Fertilizer management and light intensity showed significant variation due to the interaction effect for days required for transplanting to 1st flowering (Table 6). The highest days from transplanting to 1st flowering (36.40) was found from F_0L_1, while the lowest days (25.20) was recorded from F_2L_1.

4.5 Days required for transplanting to 1st harvesting

Significant variation was recorded in days required for transplanting to 1st harvesting for the application of fertilizer management (Table 5). The highest days from transplanting to 1st harvesting (47.61) was observed from F_0 (no fertilizer) which was statistically similar (45.77 and 46.37) with F_1 and F_3, respectively again the lowest days (42.88) from F_2.

A statistically significant difference was recorded for days required for transplanting to 1st harvesting of tomato for different levels of light intensity (Table 5). The highest days required for transplanting to 1st harvesting (47.18) was obtained from L_1 while the lowest days (45.51) was found from L_3, which was statistically identical with L_2 (44.40).

Table 5. Effect of fertilizer management and light intensity on yield contributing characters of tomato

Treatments	Days required for transplanting to 1st flowering	Days required for transplanting to 1st harvesting	Number of flower cluster/plant	Number of flowers/cluster	Number of fruits/cluster	Number of fruits/plant
Fertilizer management						
F_0	32.33 a	47.61 a	7.79 b	4.57 b	3.74 a	20.13 c
F_1	30.47 ab	45.77 a	9.59 a	5.68 a	3.37 b	25.12 b
F_2	28.67 b	42.88 b	10.09 a	5.99 a	3.99 a	28.13 a
F_3	32.40 a	46.37 a	9.98 a	6.02 a	3.80 a	25.02 a
$LSD_{(0.05)}$	2.068	1.741	0.4819	0.6206	0.3272	3.375
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Light intensity						
L_1	31.90 a	47.18 b	8.75 b	4.47 b	2.98 c	22.42 b
L_2	29.70 b	44.40 a	9.58 a	5.97 a	4.27 a	28.42 a
L_3	31.30 ab	45.51 a	9.75 a	6.25 a	3.92 b	23.02 a
$LSD_{(0.05)}$	1.791	1.507	0.4174	0.5375	0.2833	2.922
Level of significance	0.05	0.01	0.01	0.01	0.01	0.01
CV(%)	6.83	7.25	5.26	11.41	8.99	9.68

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

F_0: Control (No fertilizer application)	L_1: 50% PAR
F_1: Urea300 kg/ha + TSP200 kg/ha + MP150 kg/ha	L_2: 75% PAR
F_2: Urea350 kg/ha + TSP250 kg/ha + MP180 kg/ha	L_3: 100% PAR
F_3: Urea400 kg/ha + TSP300 kg/ha + MP210 kg/ha	

Table 6. Interaction effect of fertilizer management and light intensity on yield contributing characters of tomato

Treatments	Days required for transplanting to 1st flowering	Days required for transplanting to 1st harvesting	Number of flower cluster/plant	Number of flowers/cluster	Number of fruits/cluster	Number of fruits/plant
F_0L_1	36.40 a	52.68 a	7.77 d	4.63 b	3.93 c	25.02 d
F_0L_2	28.20 cd	43.50 ab	7.80 d	4.20 b	3.60 c	23.01 d
F_0L_3	32.40 b	47.61 a	7.80 d	4.87 b	3.70 c	22.89 d
F_1L_1	33.20 ab	50.17 bc	8.37 cd	4.13 b	2.50 d	18.07 e
F_1L_2	30.20 bc	47.30 ab	10.07 a	6.27 a	3.97 c	31.02 c
F_1L_3	28.00 cd	43.20 a	10.33 a	6.63 a	3.63 c	30.12 c
F_2L_1	25.20 d	41.40 d	9.07 bc	4.20 b	2.90 d	21.02 de
F_2L_2	29.60 bc	46.70 bc	10.50 a	6.80 a	4.83 a	37.40 a
F_2L_3	31.20 bc	46.52 abc	10.70 a	6.97 a	4.23 bc	34.39 ab
F_3L_1	32.80 ab	48.20 c	9.80 ab	4.90 b	2.60 d	21.02 de
F_3L_2	30.80 bc	47.10 a	9.97 a	6.63 a	4.67 ab	37.29 ab
F_3L_3	33.60 ab	48.92 a	10.17 a	6.53 a	4.13 bc	31.34 bc
$LSD_{(0.05)}$	3.582	3.015	0.8347	1.075	0.5667	5.845
Level of significance	0.01	0.01	0.05	0.01	0.01	0.01
CV(%)	6.83	7.25	5.26	11.41	8.99	9.68

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

F_0: Control (No fertilizer application) — L_1: 50% PAR

F_1: Urea300 kg/ha + TSP200 kg/ha + MP150 kg/ha — L_2: 75% PAR

F_2: Urea350 kg/ha + TSP250 kg/ha + MP180 kg/ha — L_3: 100% PAR

F_3: Urea400 kg/ha + TSP300 kg/ha + MP210 kg/ha

Interaction effect of fertilizer management and light intensity varied significantly for days from transplanting to 1st harvesting (Table 6). The highest days from transplanting to 1st harvesting (52.68) was observed from F_0L_1. On the other hand, the lowest days (41.40) was recorded from F_2L_1.

4.6 Number of flower cluster per plant

Number of flower cluster per plant of tomato showed significant variation due to different fertilizer management (Table 5). The highest number of flower cluster per plant (10.09) was obtained from F_2 which was statistically similar (9.98 and 9.59) with F_3 and F_1, respectively whereas the lowest number (7.79) from F_0.

Significant variation was observed for number of flower cluster per plant of tomato for different levels of light intensity (Table 5). The highest number of flower cluster per plant (9.75) was found from L_3 which was statistically identical (9.58) with L_2 and the lowest number (8.75) was obtained from L_1.

Number of flower cluster per plant varied significantly for the interaction effect of fertilizer management and light intensity (Table 6). The highest number of flower cluster per plant (10.70) was recorded from F_2L_3, while the lowest number (7.77) was attained from F_0L_1.

4.7 Number of flowers per cluster

Number of flowers per cluster of tomato showed significant variation for different fertilizer management (Table 5). The highest number of flowers per cluster (6.02) was observed from F_3 which was statistically identical (5.99 and 5.68) with F_2 and F_1, respectively and the lowest number (4.57) from F_0.

Different levels of light intensity varied significantly for number of flowers per cluster of tomato (Table 5). The highest number of flowers per cluster (6.25) was observed from L_3 which was statistically similar (5.97) with L_2 again, the lowest number (4.47) was recorded from L_1.

Interaction effect of fertilizer management and light intensity showed significant differences for number of flowers per cluster (Table 6). The highest number of flowers per cluster (6.97) was recorded from F_2L_3. On the other hand, the lowest number (4.13) was found from F_1L_1.

4.8 Number of flowers per plant

Significant variation was recorded for the number of flowers per plant of tomato for different fertilizer management (Figure 8). The highest number of flowers per plant (61.35) was observed from F_2 which was statistically similar (60.15 and 55.40) with F_3 and F_1, respectively. On the other hand, the lowest number (35.41) was recorded from F_0.

Number of flowers per plant of tomato differed significantly for the application of different levels of light intensity (Figure 9). The highest number of flowers per plant (61.72) was found from L_3 which was statistically identical (58.36) with L_2 again, the lowest number (39.15) was attained from L_1.

Interaction effect of fertilizer management and light intensity showed significant variation in terms of number of flowers per plant (Figure 10). The highest number of flowers per plant (74.54) was obtained from F_2L_3. On the other hand, the lowest number (32.84) was recorded from F_0L_2.

4.9 Number of fruits per cluster

Significant variation was recorded for the number of fruits per cluster of tomato due different fertilizer management (Table 5). The highest number of fruits per cluster (3.99) was recorded from F_2 which was statistically similar (3.80 and 3.74) with F_3 and F_0, respectively, while the lowest number (3.37) from F_1.

Application of different levels of light intensity significantly affects the number of fruits per cluster of tomato (Table 5). The highest number of fruits per cluster (4.27) was found from L_2 which was closely followed (3.92) by L_3 again, the lowest number (2.98) was observed from L_1.

Interaction effect of fertilizer management and light intensity differed significantly for number of fruits per cluster (Table 6). The highest number of fruits per cluster (4.83) was attained from F_2L_3. On the other hand, the lowest number (2.50) was observed from F_1L_1.

4.10 Number of fruits per plant

Number of fruits per plant of tomato showed significant differences for the application of fertilizer management (Table 5). The highest number of fruits per plant (28.13) was recorded from F_2 which was statistically identical (25.02) with F_3 and closely followed (25.12) by F_1, respectively. On the other hand, the lowest number (20.13) was observed from F_0.

Statistically significant variation was recorded for number of fruits per plant of tomato for application of different levels of light intensity (Table 5). The highest number of fruits per plant (28.42) was obtained from L_2 which was statistically identical (23.02) with L_3 while the lowest number (22.42) was found from L_1.

Number of fruits per plant varied significantly for the interaction effect of fertilizer management and light intensity (Table 6). The highest number of fruits per plant (37.40) was recorded from F_2L_2 and the lowest number (18.07) was attained from F_1L_1.

4.11 Length of fruit

Different fertilizer management length of fruit of tomato varied significantly (Table 7). The highest length of fruit (5.13 cm) was recorded from F_2 which was statistically identical (5.00 cm) with F_3 and closely followed (4.19 cm) by F_1, respectively. On the other hand, the lowest length (4.16 cm) was found from F_0. Silva and Vizzotto (1990) recorded largest fruits by applying $N:P_2O_5:K_2O$at 104:259:140 Kg /ha plus poultry manure at 20t/ha.

Statistically significant variation was found for length of fruit of tomato for application of different levels of light intensity (Table 7). The highest length of fruit (4.85 cm) was observed from L_2 which was statistically similar (4.81 cm) with L_3 and the lowest length (4.20 cm) was observed from L_1.

Interaction effect of fertilizer management and light intensity showed significant differences in terms of fruit length (Table 8). The highest length of fruit (5.77 cm) was recorded from F_2L_2 again the lowest length (3.57 cm) was found from F_1L_1.

4.12 Diameter of fruit

Diameter of tomato fruit varied significantly for different fertilizer management (Table 7). The highest diameter of fruit (4.61 cm) was recorded from F_2 which was statistically similar (4.56 cm) with F_3 and followed (4.07 cm) by F_1, respectively, whereas the lowest diameter (3.88 cm) was recorded from F_0.

Statistically significant difference was observed for diameter of fruit of tomato for application of different levels of light intensity (Table 7). The highest diameter of fruit (4.58 cm) was recorded from L_2 which was statistically similar (4.49 cm) with L_3, while the lowest diameter (3.76 cm) was recorded from L_1.

Fertilizer management and light intensity significantly affect on diameter of fruit for their interaction effect (Table 8). The highest diameter of fruit (5.08 cm) was recorded from F_2L_2. On the other hand, the lowest diameter (3.50 cm) was recorded from F_1L_1.

Table 7. Effect of fertilizer management and light intensity on yield contributing characters and yield of tomato

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Dry matter content/plant (%)	Dry matter content/fruit (%)	Weight of Individual fruit (g)	Yield per hectare (ton)
Fertilizer management						
F_0	4.16 b	3.88 b	7.86 c	8.74 b	76.33 b	19.48 c
F_1	4.19 b	4.07 b	8.46 b	8.96 b	81.89 a	21.61 b
F_2	5.13 a	4.61 a	9.04 a	10.44 a	87.13 a	22.65 a
F_3	5.00 a	4.56 a	8.93 ab	10.26 a	84.94 a	22.04 ab
$LSD_{(0.05)}$	0.313	0.3415	0.5470	0.5882	5.245	2.891
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Light intensity						
L_1	4.20 b	3.76 b	7.97 b	8.66 b	77.54 b	20.11 b
L_2	4.85 a	4.58 a	8.79 a	10.13 a	85.81 a	22.32 a
L_3	4.81 a	4.49 a	8.95 a	10.01 a	84.37a	21.91 a
$LSD_{(0.05)}$	0.2782	0.2957	0.4737	0.5094	4.542	2.503
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	7.12	8.16	6.53	6.26	6.50	8.67

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

F_0: Control (No fertilizer application)

F_1: Urea300 kg/ha + TSP200 kg/ha + MP150 kg/ha

F_2: Urea350 kg/ha + TSP250 kg/ha + MP180 kg/ha

F_3: Urea400 kg/ha + TSP300 kg/ha + MP210 kg/ha

L_1: 50% PAR

L_2: 75% PAR

L_3: 100% PAR

Table 8. Interaction effect of fertilizer management and light intensity on yield contributing characters and yield of tomato

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Dry matter content in plant (%)	Dry matter content in fruit (%)	Weight of Individual fruit (g)	Yield per hectare (ton)
F_0L_1	4.10 ef	3.93 bc	7.17 f	8.73 ef	70.13 e	18.00 h
F_0L_2	4.08 ef	3.67 c	8.20 cdef	8.45 ef	80.41 bcd	19.83 f
F_0L_3	4.30 de	4.03 bc	8.20 cdef	9.03 de	78.43 bcde	20.60 f
F_1L_1	3.57 f	3.50 c	7.61 ef	7.77 f	74.42 de	20.95 efg
F_1L_2	4.69 cde	4.54 ab	8.90 abcd	9.93 cd	86.82 abc	22.20 bcd
F_1L_3	4.31 de	4.17 bc	8.86 abcd	9.18 de	84.43 abcd	21.68 cde
F_2L_1	4.11 ef	3.82 c	7.91 def	8.63 ef	76.90 cde	20.33 ef
F_2L_2	5.77 a	5.08 a	9.52 ab	11.55 a	92.43 a	24.20 a
F_2L_3	5.51 ab	4.93 a	9.70 a	11.14 a	92.06 a	23.42 ab
F_3L_1	5.03 bc	3.79 c	9.21 abc	9.52 cde	88.7ab	21.15 bcd
F_3L_2	4.84 cd	5.03 a	8.55 bcde	10.58 abc	83.56 abcd	23.03 abc
F_3L_3	5.14 bc	4.85 a	9.02 abc	10.69 ab	82.57abcd	21.95 bcd
$LSD_{(0.05)}$	0.5565	0.5914	0.9473	1.019	9.085	1..271
Level of significance	0.01	0.01	0.05	0.01	0.05	0.05
CV(%)	7.12	8.16	6.53	6.26	6.50	5.98

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

F_0: Control (No fertilizer application)

F_1: $_{\text{Urea300 kg/ha}}$ + $_{\text{TSP200 kg/ha}}$ + $_{\text{MP150 kg/ha}}$

F_2: $_{\text{Urea350 kg/ha}}$ + $_{\text{TSP250 kg/ha}}$ + $_{\text{MP180 kg/ha}}$

F_3: $_{\text{Urea400 kg/ha}}$ + $_{\text{TSP300 kg/ha}}$ + $_{\text{MP210 kg/ha}}$

L_1: 50% PAR

L_2: 75% PAR

L_3: 100% PAR

4.13 Dry matter content in plant

Application of different fertilizer management varied significantly for dry matter content in tomato plant (Table 7). The maximum dry matter content in plant (9.04%) was obtained from F_2 which was statistically similar (8.93%) with F_3 and followed (8.46%) by F_1, respectively, while the minimum (7.86%) from F_0.

Dry matter content in plant showed statistically significant differences for application of light intensity (Table 7). The maximum dry matter content in plant (8.95%) was recorded from L_3 which was statistically identical (8.79%) with L_2 again, the minimum (7.97%) from L_1.

Interaction effect of fertilizer management and light intensity showed significant variation in terms of dry matter content in plant (Table 8). The maximum dry matter content in plant (9.70%) was attained from F_2L_3 and the minimum (7.17%) was obtained from F_0L_1.

4.14 Dry matter content in fruit

Dry matter content in fruit of tomato differed significantly due to the application of different levels of fertilizer management (Table 7). The maximum dry matter content in fruit (10.44%) was recorded from F_2 which was statistically identical (10.26%) with F_3 and flowed (8.96%) by F_1, respectively. On the other hand, the minimum (8.74%) was attained from F_0.

Statistically significant variation was observed for dry matter content in fruit for application of different levels of light intensity (Table 7). The maximum dry matter content in fruit (10.13%) was observed from L_2 which was statistically similar (10.01%) with L_3, whereas the minimum (8.66%) was recorded from L_1.

Interaction effect of fertilizer management and light intensity showed significant variation in terms of dry matter content in fruit (Table 8). The maximum dry matter content in fruit (11.55%) was obtained from F_2L_2. On the other hand, the minimum (7.77%) was recorded from F_1L_1.

4.15 Weight of Individual fruit

Weight of individual fruit of tomato varied significantly for different fertilizer management (Table 7). The highest weight of individual fruit (87.13 g) was found from F_2 which was statistically identical (84.94 g and 81.89 g) with F_3 and F_1, respectively. The lowest weight (76.33 g) was observed from F_0 (no fertilizer).

Application of different levels of light intensity showed statistically significant differences for weight of individual fruit (Table 7). The highest weight of individual fruit (85.81 g) was found from L_2 which was statistically identical (84.37 g) with L_3. On the other hand, the lowest weight (77.54 g) was obtained from L_1.

Significant variation was recorded for the interaction effect of fertilizer management and light intensity for weight of individual fruit (Table 8). The highest weight of individual fruit (92.43 g) was recorded from F_2L_2, while the lowest weight (70.13 g) was observed from F_0L_1.

4.16 Yield per plant

Yield per plant of tomato varied significantly due to different fertilizer management (Figure 11). The highest yield per plant (4.35 kg) was observed from F_2 which was closely followed (4.23 kg) by F_3 and the lowest yield (3.74 kg) was recorded from F_0 which was followed (4.15 kg) by F_1.

Statistically significant variation was recorded for different levels of light intensity in terms yield per plant (Figure 12). The highest yield per plant (3.58 kg) was found from L_2 which was statistically similar (3.39 kg) with L_3 again, the lowest yield (1.99 kg) from L_1.Rao and Mitra(1998) reported that photo synthetically active radiation is the major factor regulating photosynthesis yield of crops.

Interaction effect of fertilizer management and light intensity showed significant differences for yield per plant of tomato (Figure 13). The highest yield per plant (4.68 kg) was recorded from F_2L_2 whereas, the lowest yield (1.56 kg) was recorded from F_1L_1). It was observed that optimum doses of fertilizer management ensured optimum vegetative and reproductive growth and the ultimate results was the highest yield.

4.17 Yield per hectare

Significant variation was recorded for yield per hectare due to the different fertilizer management (Table 7). The highest yield per hectare (22.65 ton) was obtained from F_2 which was statistically similar (22.04 ton) with F_3 and followed (21.61 ton) by F_1, respectively, while the lowest yield (19.48 ton) from F_0. Mohd et al (2002) to revealed that application of recommended doses of fertilizers (50% of the recommended dose of fertilizer of 100:50:50 NPK kg /ha) resulted in the highest yield high quality. Pansare et al. (1994) found that the maximum yield of high quality tomatoes was obtained when straight fertilizers were added in the N,P,K ratio of 3:2:1 (150 Kg N/ha,50 Kg P_2O_5/ha, 100 Kg K_2O/ha). Silva and Vizzotto (1990) recorded the highest yields (53t/ha) by applying N:P_2 O_5 : k_2o AT 104:259 :140 Kg/ha

Yield per hectare of tomato varied significantly for the application of different levels of light intensity (Table 7). The highest yield per hectare (22.32 ton) was recorded from L_3 which was statistically identical (21.91 ton) with L_2 and the lowest yield (20.11 ton) from L_1 Kuo et all 1978 reported that high light intensity accompanied by high temperature are harmful fruit-set that leads to lower yield. On the other hand plants grown under shading, showed decreased photosynthesis which ultimately affect yield and fruit quality (Morgan et al.,1985)

Interaction effect of fertilizer management and light intensity differed significantly for yield per hectare of tomato (Table 8). The highest yield per hectare (44.97 ton) was observed from F_2L_2. On the other hand, the lowest yield (35.74 ton) was recorded from F_0L_1.

4.18 Economic analysis

Input costs for land preparation, seed cost, fertilizer cost and man power required for tomato cultivation for unit plot and converted into cost per hectare. Prices of tomato were considered in market rate basis. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings-

4.18.1 Gross return

In the combination of fertilizer management and light intensity different gross return was recorded under the trial (Table 9). The highest gross return (Tk. 605,000) was obtained from F_2L_2 and the second highest gross return (Tk. 585,500) was obtained in F_2L_3. The lowest gross return (Tk. 360,000) was obtained from F_0L_1.

Table 9. Cost and return of tomato cultivation as influenced by fertilizer management and light intensity

Treatment Combination	Cost of production (Tk./ha)	Yield of tomato (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
F_0L_1	227,538	18.00	360,000	132,462	1.58
F_0L_2	227,538	19.83	495,750	268,212	2.18
F_0L_3	227,538	20.60	515,000	287,462	2.26
F_1L_1	248,274	20.95	523,750	275,476	2.11
F_1L_2	248,274	22.20	555,000	306,726	2.24
F_1L_3	248,274	21.68	542,000	293,726	2.18
F_2L_1	252,645	20.33	508,250	255,605	2.01
F_2L_2	252,645	24.20	605,000	352,355	2.39
F_2L_3	252,645	23.42	585,500	332,855	2.32
F_3L_1	257,017	21.15	528,750	271,733	2.06
F_3L_2	257,017	23.03	575,750	318,733	2.24
F_3L_3	257,017	21.95	548,750	291,733	2.14

Cost of tomato @ Tk. 20,000/ton

4.18.2 Net return

In case of net return, different treatment combination showed different result (Table 9). The highest net return (Tk. 352,355) was obtained from F_2L_2 and the second highest net return (Tk.332, 855) was obtained from F_2L_3. The lowest net return (Tk. 132,462) was obtained from F_0L_1.

4.18.3 Benefit cost ratio (BCR)

The combination of fertilizer management and light intensity for benefit cost ratio was different in all treatment combination (Table 9). The highest (2.39) benefit was performed from F_2L_2 and the second highest benefit cost ratio (2.32) was estimated F_2L_3. The lowest benefit cost ratio (1.58) was obtained from F_0L_1. From economic point of view, it is apparent from the above results that F_2L_2 treatment combination was the more profitable than rest of the treatment combinations under the study for tomato production.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from April to October 2011 to find out the find out the effect of light intensity and fertilizer management on growth and yield of summer tomato. The experiment consisted of two factors. Factor A: Factor A: Light intensity (three levels) as L_1: 50% PAR (Photo-synthetically Active Radiation); L_2: 75% PAR; L_3: 100 PAR and Factor B: Fertilizer management (Four levels) as F_0: Control (No fertilizer application); F_1: $Urea_{300\ kg/ha}$ + $TSP_{200\ kg/ha}$ + $MP_{150\ kg/ha}$; F2: $Urea_{350\ kg/ha}$ + $TSP_{250\ kg/ha}$ + $MP_{180\ kg/ha}$ and F_3: $Urea_{400\ kg/ha}$ + $TSP_{300\ kg/ha}$ + $MP_{210\ kg/ha}$. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Data on different growth parameters and yield of tomato was recorded.

At 20, 30, 40, 50 and 60 DAT, the longest plant (27.44 cm, 38.17 cm, 53.18 cm, 70.22 cm and 84.70 cm) was recorded from F2, whereas the shortest (20.64 cm, 29.67 cm, 44.05 cm 59.33 cm and 67.08 cm) from F_0 . At 20, 30, 40, 50 and 60 DAT, the maximum number of leaves per plant (6.59, 16.51, 28.93, 36.62 and 50.33) was Found from F2 whereas the minimum number (4.77, 13.86, 24.47 29.63 and 40.16) from F_0. At 20, 30, 40, 50 and 60 DAT, the maximum number of branches per plant (5.35, 8.14, 12.81, 18.53 and 23.37) was recorded from F2, while the minimum number (4.42, 6.51, 9.76, 13.02 and 18.46) from F_0. The highest days from transplanting to 1^{st} flowering (32.40)was Found from F3 and lowest day (28.67) was recorded from F2. The highest days from transplanting to 1st harvesting (70.61) was observed from Fo, again the lowest days (65.88)from F_2. The highest number of fruits per plant (40.96) was recorded F2 and lowest number (30.04) was observed from F_0. The highest length of fruit (5.13) cm was recorded from F_2 and lowest length (4.16 cm)was recorded from F_0. The highest diameter of fruits (4.61cm) was recorded from F_2,whereas the lowest diameter (3.88 cm)was recorded from F_0. The maximum dry maintain content in plant (9.04%)was obtained from F2 while the minimum (7.86%) from F_0. The Maximum dry matter content in fruit (10.44%) was recorded from F_2 and minimum (8.74%)was attained from F_0. The highest weight of individual fruit(87.13 g) was Found F_2 again the lowest weight (76.33 g) from F_0. The highest yield per hectare (22.65 ton)was obtained from F_2 and lowest yield (19.48 ton)from F_0.

At 20, 30, 40, 50 and 60 DAT, the longest plant (26.11 cm, 36.71 cm, 52.83 cm, 70.06 cm and 84.32 cm) was obtained from L_3 again the shortest plant (20.77 cm, 31.99 cm, 44.49 cm, 60.72 cm and 70.96 cm) was recorded from L_1. At 20, 30, 40, 50 and 60 DAT, the maximum number of leaves per plant (6.43, 16.60, 28.83, 35.85 and 52.16) was recorded from L_3 again, the minimum number (5.53, 14.26, 25.25, 32.71 and 37.62) from L_1. At 20, 30, 40, 50 and 60 DAT, the maximum number of branches per plant (5.67, 8.31, 12.49, 17.59 and 23.62) was attained from L_3 and the minimum number (3.98, 6.23, 10.70, 15.22 and 19.38) from L_1.The highest day required For transplanting to flowering (31.90) was recorded from L_1 again the lowest day (29.70) was obtained from L_2. The highest days required from transplanting to 1st harvesting (70.26)was obtained from L_1 while the lowest day (67.34)was Found L_3. The highest number of fruits per plant (39.03) was obtained from L_2 while the lowest number (31.45) was Found L_1. The highest length of fruits (4.85 cm) was observed from L_3 and lowest (4.20) was observed from L_1.The highest diameter (3.76 cm) was recorded from L_1, the maximum dry matter content in plant (8.95%) was recorded from L3 and minimum (7.97%) from L_1. The maximum dry matter content in fruit (10.13%) was observed from L_2, whereas the minimum (8.66%) from L_1. The highest weight of individual fruit (85.81g) was Found from L2 and the lowest weight(77.54g) from L_1. The highest yield per hectare (22.32 ton)was recorded from L2 and lowest yield (20.11) from L_1.

At 20, 30, 40, 50 and 60 DAT, the longest plant (31.52 cm, 42.03 cm, 58.86 cm, 76.27 cm and 96.94 cm) was Found from F_2L_2, while the shortest plant (19.61 cm, 28.53 cm, 42.95 cm 57.60 cm and 65.11 cm) from F_0L_0. At 20, 30, 40, 50 and 60 DAT, the maximum number of leaves per plant (7.30, 17.97, 31.07, 39.37 and 61.33) was observed from F_2L_2 and the minimum (4.73, 13.60, 23.87, 28.97 and 35.33) from F_0L_0. At 20, 30, 40, 50 and 60 DAT, the maximum number of branches per plant (6.50, 9.42, 13.85, 20.45 and 26.13) was observed from F_2L_2 whereas the minimum (4.22, 6.12, 9.14, 12.44 and 17.33) from F_0L_0.The highest day from transplanting to 1st flowering (36.40) was Found from F_3 and the lowest day (25.20) was recorded from F_2. The highest days from transplanting to 1st harvesting (74.70) was observed from F_0, again the lowest days (65.33) from F_2. The highest number of fruits per plant (49.05) was recorded from F2 and the lowest number (26.72) was attained from F_1L_1. The highest length of fruit (5.77cm) was recorded from F_2 L_2 again the lowest length (3.57 cm) was Found from F_1L_1. The highest diameter of fruit (5.08 cm) was recorded from F_2 L_2, and the lowest diameter (3.50 cm) was recorded from F_0 L_1. The maximum dry matter content in plant (9.70%) was attained from F_2 L_3 while the minimum (7.17%) from F_0 L_1. The maximum dry matter content in fruit (11.55%) was recorded from F_2 L_2 and the minimum (7.77%) was attained from F_0. The highest weight of individual fruit (92.43 g) was Found from F_2 L_2 again the lowest weight (70.13 g) from F_0 L_1. The highest yield per hectare (24.20 ton) was observed from F_2 L_2 and the lowest yield (18.00 ton) from F_0 L_1.

The highest net return (Tk. 352,355) was obtained from F_2L_1 and the lowest net return (Tk. 132,462) was obtained from F_0L_1. The highest (2.39) benefit was performed from F_2L_2 and the lowest (1.58) was obtained from F_0L_1.

Considering the findings of the present experiment, Following conclusion may be drawn:

1. To furnish precise result another light intensity and fertilizer management and may be included.
2. Before recommendation of light intensity and fertilizer management to optimize tomato production further study is needed in different agro-ecological zones of Bangladesh For regional adaptability.

APPENDICES

Appendix I. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Garden , SAU, Dhaka
AEZ	Madhupur Tract (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
Textural class	silty-clay
pH	5.6
Organic carbon (%)	0.45
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, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from April to October 2011

Month (2011)	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
April	33.6	23.6	69	163	6.4
May	36.7	20.3	70	205	7.7
June	35.4	22.5	80	577	4.2
July	36.0	24.6	83	563	3.1
August	36.0	23.6	81	319	4.0
September	34.8	24.4	81	279	4.4
October	34.8	18.0	77	227	5.8

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix III. Analysis of variance of the data on plant height as influenced by light intensity and fertilizer management of tomato

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	1.218	4.911	4.009	13.945	0.459
Light intensity (A)	2	86.790**	122.569**	141.110**	224.420**	609.070**
Fertilizer (B)	3	89.853**	72.677**	242.491**	294.771**	563.175**
Interaction (A×B)	6	17.044**	18.203*	38.484*	44.258*	154.066**
Error	22	4.468	5.697	14.017	15.392	28.665

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant as influenced by light intensity and fertilizer management of tomato

Source of variation	Degrees of freedom	Mean square				
		Number of leaves per plant at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.116	0.588	1.820	0.385	18.882
Light intensity (A)	2	6.460**	13.966**	41.601**	96.059**	167.379**
Fertilizer (B)	3	2.704**	19.042**	45.048**	29.677**	619.479**
Interaction (A×B)	6	0.491*	2.677*	6.555*	6.788*	134.058**
Error	22	0.164	0.924	2.246	2.063	20.589

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of branches per plant as influenced by light intensity and fertilizer management of tomato

Source of variation	Degrees of freedom	Mean square				
		Number of branches per plant at				
		20 DAT	30 DAT	40 DAT	50 DAT	60 DAT
Replication	2	0.032	0.233	0.274	1.263	1.231
Light intensity (A)	2	1.534**	5.387**	17.580**	54.522**	46.864**
Fertilizer (B)	3	9.894**	14.992**	9.622**	17.586**	55.717**
Interaction (A×B)	6	1.607**	2.669**	2.728*	4.232*	9.693**
Error	22	0.231	0.345	0.809	1.277	2.726

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing characters of tomato as influenced by light intensity and fertilizer management of tomato

Source of variation	Degrees of freedom	Mean square						
		Days required for transplanting to 1st flowering	Days required for transplanting to 1st harvesting	Number of flower cluster/ plant	Number of flowers/ cluster	Number of flowers/ plant	Number of fruits/ cluster	Number of fruits/plant
Replication	2	1.053	0.136	0.217	0.437	9.698	0.051	24.240
Light intensity (A)	2	28.387**	49.222**	10.301**	4.194**	1307.907**	0.612**	246.098**
Fertilizer (B)	3	15.520*	58.334**	3.443**	11.062**	1779.201**	5.301**	883.235**
Interaction (A×B)	6	30.187**	13.325**	0.817*	1.604**	265.585**	0.984**	124.792**
Error	22	4.475	3.170	0.243	0.403	34.153	0.112	11.915

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

Appendix VII. Analysis of variance of the data on yield contributing characters of tomato as influenced by light intensity and fertilizer management of tomato

Source of variation	Degrees of freedom	Mean square						
		Length of fruits (cm)	Diameter of fruits (cm)	Dry matter content/plant (%)	Dry matter content/fruits (%)	Weight of Individual fruit (g)	Yield (kg/plant)	Yield (kg/ha)
Replication	2	0.144	0.040	0.018	0.033	16.412	0.236	1.658
Light intensity (A)	2	2.410**	1.177**	2.615**	6.886**	197.557**	3.356**	304.413**
Fertilizer (B)	3	1.577**	2.430**	3.272**	7.919**	234.205**	9.037**	90.191**
Interaction (A×B)	6	0.629**	0.425**	0.894*	1.550**	84.296*	0.975**	29.323*
Error	22	0.108	0.122	0.313	0/362	28.785	0.133	8.743

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