EXPERIMENTAL INVESTIGATION ON IMPACT OF BIO AND ORGANOMINERAL FERTILIZES ON COMPOSITION AND SHELF LIFE OF TOMATO (*LYCOPERSICON ESCULENTUM*) FRUIT.

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ABSTRACT:- The present investigation was aimed to evaluate the impact of different nutrient sources viz., bio-fertilizer (effective microorganisms) with or without organic manure (Farmyard Manure) and inorganic fertilizer (NPK) on the quality characteristics of tomato. The pot experiment was conducted by combining 7 treatments in completely randomized design with 3 replications. The results revealed that nutrient sources significantly affected different quality parameters including; physicochemical (vitamin C, lycopene, total soluble solids and pericarp thickness); sensory (fruit color, fruit flavor and fruit firmness) and shelf life. It was concluded that bio-fertilizer integrated with Farmyard Manure emerged as better nutrient source over other treatments. Benefits of bio fertilizer application were more in the presence of Farmyard Manure on quality of tomato in comparison with NPK. No work has been previously published to study the effect of effective microorganisms on taste active components of vegetable or fruit crops, and their correlation with physicochemical attributes and shelf life. Data are provided for the researchers for further investigation.

Key Words: Lycopersicon esculentum; Bio Fertilizer; Quality; Shelf Life; Physicochemical Characters; Sensory Characters; Pakistan.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is a herbaceous plant. It provides a variety of phytonutrients which are often associated with lycopene and vitamin C (Rocha et al., 2013). The quality of tomato fruit determines its suitability for use both as fresh vegetable and for processing (Branthome, 2010). Fruit quality attributes (physicochemical, nutritional, organoleptic and shelf life) are important features for tomato either it is used fresh or is processed (Javaria et al., 2012 a). The post-harvest losses of tomato fruit in Pakistan accounts for 35-40% of horticulture produce. The soften-ing that accompanies ripening of fruits makes worse damage during shipping and handling processes (FAO, 2002). According to FAO (2013) food quality is an important issue for consumers' protection, and hence it is an essential marketing criterion. Commercial farming in Pakistan is still relying on inorganic fertilizers for growing vegetables (Saidu et al., 2011). The main reason is these are easy to use, rapidly absorbed and used by the vegetables. However, inorganic fertilizers are believed to contribute

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environmental pollution and human food intoxication. The high price of inorganic fertilizers and their limited supply at the time of need not only discourage the farmers but also has made prices of agricul-tural commodities skyrocket.

On the other hand, organic manures have great impact on soil water holding capacity, soil texture and structure, aeration. Moreover, slow releases of nutrients improve quality of produce (Stolz et al., 2011). However, organic materials like FYM are used for rising crop yield but pure organic farming can never meet the increasing demand for nutrient supply, because sufficient quantities of organic materials are not obtainable.

Another way of supplying nutrients to soil is through biological source, called effective microorganisms (Higa, 2012). The biofertilizer is a mixed culture of beneficial microorganisms that can be applied as inoculants to increase the microbial diversity of soil. The microorganisms contained in bio-fertilizer produce beneficial plant hormones and antioxidants (Siqueira et al., 2012). A small dose of biofertilizer is enough to produce required outputs because each gram of biofertilizers contains at least 10 million viable cells of a specific strain (Anandaraj and Delapierre, 2010). Hence, EM is attracting interest in sustainable agriculture (Javaid, 2010). The integrated use of bio fertilizer with other nutrient sources may solve the above problems.

Therefore, this study was conducted to develop a production system for the efficient utilization of mineral and/or organic nutrient resources by integrating with bio-fertilizer to evaluate overall quality of tomato.

MATERIALS AND METHOD

The study was conducting at Gomal University, Dera Ismail Khan. The soil used in the experiment was sandy loam textured with 0.92% organic matter, 0.04% nitrogen, 12 μ g g^{-1} soil available phosphorous, 102.15 μ g g^{-1} soil available potassium and pH 7.8. Meteorological data of the experimental site is given in Figure 1 (PMD, 2012).

Nursery Raising

Tomato (cv Galia) was used as a test crop. Galia is hybrid seed variety, with 99 % purity, and 85 % minimum germination. This variety is very suitable for agro-climatic conditions of arid area and it is farmers' first choice in this region. One month old seedlings raised in seed bed were transplanted to the pots. The uniformed sized tomato seedlings (10 cm tall with 3-5 true leaves) were transplanted in the earthen pots.

Soil Amendments

About 35 cm deep and having 95cm diameter earthen pots were

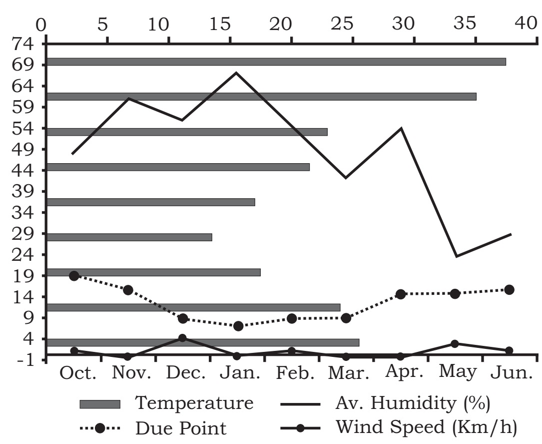


Figure 1: Meteorological data (month-wise) for D.I.Khan area recorded during cropping season (2012-2013)

filled with 21 kg soil each. Fertilizers used was 100 kg N ha^{-1} in the form of urea, 60 kg K_2O in the form of Sulphate of Potash (SOP), 80 kg P_2O_5 ha^{-1} in the form of single super phosphate, 600 kg Bio Khad as a source of EMs and FYM 15 t ha^{-1} were applied to tomato plants as per treatment. Quantities of fertilizers for a pot were calculated by the method described by Yellamanda and Sankara (2002).

Treatments and Experimental Design

Treatments were: T_1= Control (without any fertilizer); T_2 = Farm Yard Manure (FYM); T_3= EM (Bio Khad); T_4= NPK ; T_5= NPK+FYM ; T_6= EM+FYM; T_7= EM+NPK. Each treatment was replicated thrice. Pots were arranged in completely randomized design (CRD) in rope mesh house under natural environmental conditions.

Harvesting Schedule

Harvesting was started during the last week of March, when the tomatoes attained the table-ripe maturity as determined by USDA (2010) and ended in June. Five tomatoes were randomly selected per each replicate per respective treat-ment(s) for further study.

Evaluation of Physico Chemical Attributes of Tomato Fruit

The tomato fruits were divided into two halves, one half was further divided into two wedges for sensory analysis. The remaining halves for each treatment were mixed and used for chemical analysis. Vitamin C, total soluble solids and lycopene were extracted and estimated by the method as described by A.O.A.C (2001). High precision digital vernier calliper was used to measure pericarp thickness of tomato fruit.

Evaluation of Sensory Attributes of Tomato Fruit

A group of twenty evaluators was semi trained in descriptive analysis according to guidelines of ISO (1993). Samples of each treatment were served on white plates coded with a 3-digit number in arbitrary order to each evaluator. The panel was trained with respect to aptitude to categorize. The evaluation was carried out using a 20 cm line scale with affix points 'none' on the left side and 'very much' on the right side. While choosing the panelists following criteria were kept in mind i) their ages were between 20 and 59 years, ii) able to pass a flavor sharpness test. During sensory analysis panel was directed to clean their mouths with a piece of bread and mineral water to vanish the taste of former sample.

Evaluation of Shelf Life of Tomato Fruit

In the end of March, when the tomatoes reached the table ripe stage of maturity, determined visually by the USDA (2010), they were harvested and subjected to evaluate the shelf life of tomato fruits. Shelf life/ marketable yield or storability of tomato fruits is very important parameter. Shelf life of tomatoes was evaluated on the basis of general appearance (for rotting, microbial infection, color, gloss, tightness), wilting and drying of calyx, and taste (Mondal, 2000).

Statistical Analysis

The data were analyzed with analysis of variance (ANOVA) according to Steel et al. (1997) and LSD was used to assess the location of the significant differences.

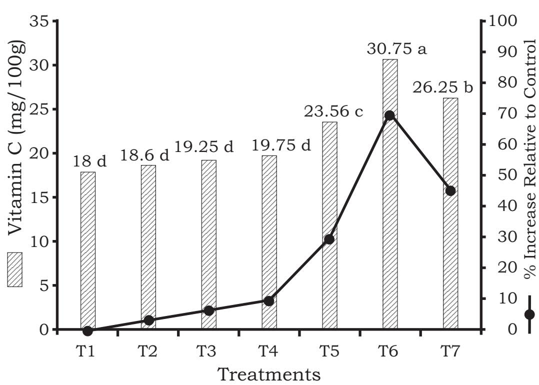
RESULTS AND DISCUSSION

FYM was analyzed for its composition; it contained 0.6% nitrogen, 0.45% phosphorous, 1% potassium, 15.3% organic matter, 0.16% calcium, 0.04% sulphur, 0.04% Zn, 0.6% iron and boron in traces. While Bio-khad contained microbial mixture of yeast, lactic acid bacteria, photosynthetic bacteria and actinomycetes.

Physicochemical Attributes

Vitamin C (mg 100g^{-1})

Vitamin C is vital nutrient for the human body because it helps the body to absorb iron, heals the wounds and helps to fight infections. It is key component of tomato fruit (Kavitha et al., 2012). Vitamin C was significantly affected by some of the soil amendments (Figure 2). The data showed that tomato plants amended with EM+FYM (T_6) possessed the maximum vitamin C content (30.75 mg/100g) followed by 26.25 mg/100g vitamin C in tomatoes amended with NPK+FYM (T_7) and 23.56mh/100g in fruits supplied with NPK+FYM (T_5) (Figure 2). The rest of the treatments contained statistically similar amount of vitamin C. The lowest vitamin C content was produced in control treatment. This observation is corroborated with the findings of Jaya and Sunita (2014), who found a significant positive effect of EM on fruit quality when it was applied in combination with organic manure. The reason might be culture of effective microorganisms increased the efficiency of micro and macro nutrient supply by organic manure which improved fruit cell metabolisms necessary for the production of vitamin C.

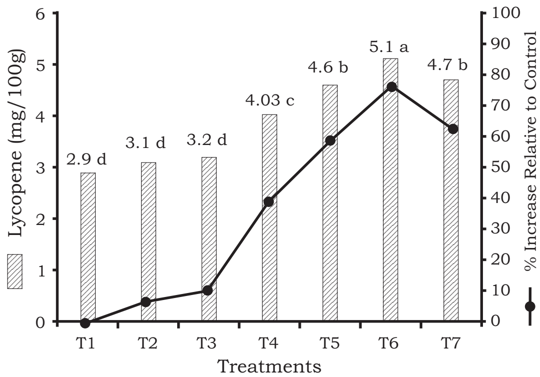


T_1 (Control), T_2 (FYM), T_3 (EM), T_4 (NPK), T_5 (NPK+FYM), T_6 (EM+FYM), T_7 (EM+NPK)

Figure 2. Effect of different soil amendments on vitamin C (mg/100g) of tomato fruit. Different letters indicate significant differences ($p \leq 0.05$) according to least significant difference

Lycopene (mg 100g^{-1})

Data indicated that there was no significant difference in lycopene content of fruits among sole applications of FYM (T_2), EM (T_3) and control (T_1). While, tomatoes amended with EM+FYM (T_6) produced maximum lycopene (5.1 mg 100g^{-1}) that differed significantly from all other treatments (Figure 3). It was followed by lycopene content 4.70 mg 100g^{-1} in tomatoes grown in pots amended with EM+NPK (T_7) and NPK+FYM (T_5) with lycopene content of 4.6 mg 100g^{-1} and both treatments were statistically alike. The results are in line with the results of Jaya and Sunita. (2014), who noted the similar trend in terms of carotenoids in spinach. The reason might be EM contains lactic acid bacteria, yeasts and photosynthetic bacteria which have the ability to effectively mineralize soil organic matter and consequently improve nutrient availability to the produce to attain good quality as Sumalee et al. (1996).



T_1 (Control), T_2 (FYM), T_3 (EM), T_4 (NPK), T_5 (NPK+FYM), T_6 (EM+FYM), T_7 (EM+NPK)

Figure 3. Effect of different soil amendments on Lycopene (mg/100g) of tomato fruit. Different letters indicate significant differences ($p \leq 0.05$) according to least significant difference

Total Soluble Solids (TSS)

The data showed that the effect of soil amendments on total soluble solids (TSS) of tomato fruit was significant (Figure 4). The minimum TSS content (4.9 g) was observed in control (T_1). The effect was more pronounced when EM as applied with FYM (T_6), it gave 42% increase over control. The results are in harmony with the results of Higa and Parr (1994); Densilin et al. (2010), who found that with the application of EM+FYM, population of micro-organisms that are beneficial for plant growth and quality increased, resulting in more rapid minera-lization of organic matter, suppre-ssion of soil-borne pathogens and increased produce quality (Kavitha et al., 2012).

Pericarp Thickness (mm)

Thickness of tomato fruit pericarp was significantly affected by treatments (Figure 5). Data showed that thickest pericarp (3.80 mm) was found in tomatoes applied with EM+ FYM (T_6), followed by EM+NPK (T_7) and NPK+FYM (T_5) with pericarp thickness of 3.68 mm and 3.65 mm, respectively. All the three treatments were statistically alike. The lowest thickness (2.82 mm) was recorded in tomatoes applied with no nutrient (control), which was statistically

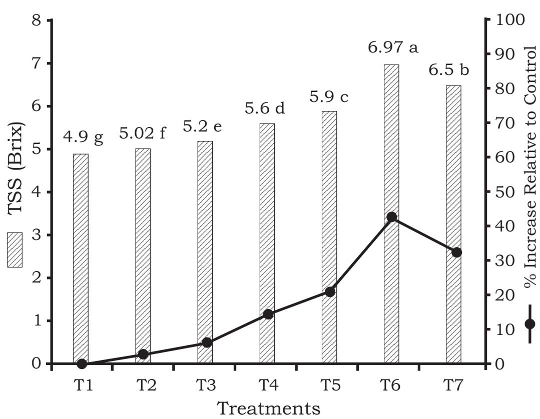


Figure 4. Effect of different soil amendments on total soluble solids (Brix) of tomato fruit. Different letters indicate significant differences ($p \leq 0.05$) according to least significant difference

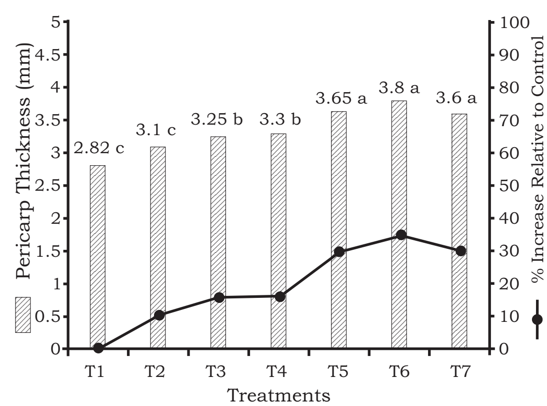


Figure 5. Effect of different soil amendments on pericarp thickness (mm) of tomato fruit. Different letters indicate significant differences ($p \leq 0.05$) according to least significant difference

similar to tomatoes supplied with FYM (T_2). The additional plant nutrients likely to be available to tomatoes amended with EM+FYM (T_6) might have increased the pericarp thickness. The reason may be continuous release of micro and macro nutrients to plant characterized by EM+FYM might have continuously increased protein and starch content of the fruits which increased fruit pericarp thickness (Ncube and Calistus, 2012; Arshad and Frankenberger, 1992).

Organoleptic Attributes

During ripening of tomato, many physical and chemical changes take place which have a significant influence on sensory characteristics of produce (Butt and Al-Haq, 1991). The important sensory features include colour, firmness and flavor of horticultural produce. These traits are very important regarding acceptability of fruit as a food and for the marketing (Javaria et al., 2012 b).

Color

The data (Figure 6) showed that all the treatments had significant effect on the color of tomato fruit (surface and tissue redness). The highest mean score (9.5) for color was given to tomatoes applied with EM+FYM (T6), while the lowest was given to the tomatoes in control treatment (8.0). The reason of the higher color intensity in tomatoes applied with EM+FYM might be due to higher lycopene content, as the lycopene increases tomato fruit attains rich red color (Shiboob, 2000).

Fruit Firmness.

Fruit firmness was affected significantly due application of bio, organic and inorganic fertilizers

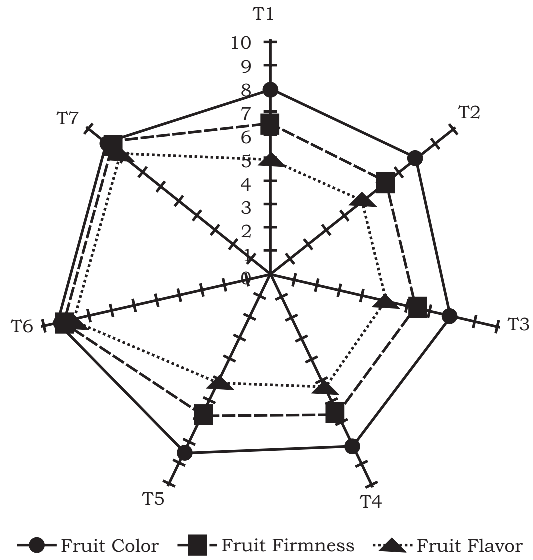


Figure 6. Effect of different soil amendments on organoleptic attributes of tomato fruit

(Figure 6). The highest score (9.2) was recorded for tomatoes amended with EM+FYM (T6), while the lowest score (6.5) was recorded in tomatoes harvested from control treatment. The reason might be EM increased the efficiency of micro and macro nutrient supply by organic fertilizer. These micro and macronutrients are essential for cell wall structure and function of fruit by stabilizing peptic networks and regulating cell wall pore size which makes the fruit firm (Davis et al., 2003).

Flavor

The data indicated that flavor of tomatoes was influenced significantly by soil nutrient applications (Figure 6). The highest score was awarded to tomatoes applied with EM+FYM (9.0), followed by tomatoes applied with EM+NPK obtaining 8.5 score and both treatments differed significantly. Lowest score was given to control (5.0), which statistically identical to T2 (FYM), T3 (EM), T4 (NPK) and T5

(FYM+NPK) in terms of flavor. The reason might be low moisture content has been reported as an indicator for good taste (Shamshad et al., 2001; Auerswald et al., 1999). As shown earlier EM+FYM increased TSS in tomato fruit (Figure 4). Moreover, high quality flavor fruits are proved to have less water percentage or increased TSS contents.

Correlation studies

Results of correlation studies indicated highly significant positive correlation among chemical, sensory and storability characteristics (Table 1). The correlation studies signify the importance of fruit components in establishing fruit quality and higher shelf life. These results are supported by the research conclusion of Wuzhong et al. (2001?); Shashidhara and Mathad (2008), who observed highly significant correlation among the physicochemical attributes and yield of tomato fruit.

Shelf Life

Steven and Celso (2005) found that shelf life of horticultural product could be accessed by percent marketable yield. Marketable yield (%) of tomato fruit could be evaluated by the various attributes including; fruit free of rotting, microbial infection and appearance during storage. The data showed that treatments improved the tomato storability (Figure 7). It is also clear that the effect of sole application of FYM was non-significant and inconsistent on fruit health and marketable yield during 12 days of storage at room temperature, however

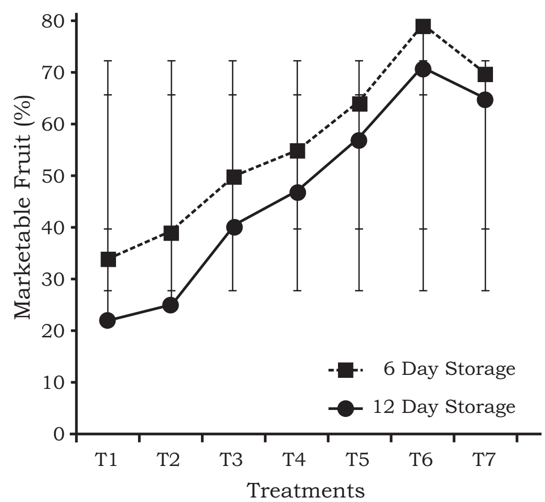


Figure 7. Effect of different soil amendments on storability (Marketable fruit %) of tomato fruit.

Table 1. Correlation studies among fruit quality and storability components

	Lycopene	TSS	Fruit color	Pericarp thickness	Fruit firmness	Fruit flavor	Yield / Plant(Kg)
Lycopene	1						
TSS	0.96**	1					
Fruit color	0.94**	0.95**	1				
Pericarp thickness	0.92**	0.91**	0.93**	1			
Fruit firmness	0.93**	0.92**	0.99**	0.75**	1		
Fruit flavor	0.94**	0.90**	0.99**	0.92**	0.99**	1	
Shelf life (1fter 12 days)	0.96**	0.96**	0.93**	0.97**	0.92**	0.92**	1

when EM and FYM were integrated it showed remarkable increase in storability of tomato fruit. EM and NPK also improved the storability of tomato relative to other treatments but not as much as EM +FYM did. The reason could be the enhanced colonization by mycorrhiza in EM treated plants which improved the release of calcium and zinc from FYM and enhanced its uptake, resulting in better storability of produce (Ncube and Calistus (2012); Rukhsana et al., 1999). Before this study it was not confirmed whether the improvement in storability is due to thicker pericarp and/or higher TSS and higher pulp content (Ghorbani et al. (2008). In this experiment it was also affirmed that the improvement in shelf life of tomato fruit is due to thicker pericarp and higher total soluble solids (Table 1).

It is concluded that EM gives good results if amended with FYM rather than NPK. It is an innovative, environment and soil friendly phytonutrient and due to its advantageous effect on tomato fruit quality and shelf life it seems advisable to researchers to conduct trials to assess the effects of EM technology on the quality of other vegetables like spinach, carrot and radish.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

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1.	Dr. Sadaf Javaria	Concived the idea, Data Collection
2.	Dr. Muhammad Qasim Khan	Result and Discussion, Data Collection, Did SPSS Analysis
3.	Dr. KashifWaseem	Data Collection, Wrote Abstract, Methodology,
4.	Dr. MuhammadSaleemJilani	Technical input at every step
5.	Dr. Habib urRehman	Methodology, Introduction, References
6.	Mr. Muhammad Sohail	Overall management of the article
7.	Dr. Muhammad Sohail Khan	Did SPSS Analysis, Result and Discussion, Methodology

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