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Effect of different soil pHs and phosphorous concentrations on quantitative and qualitative characteristics of Tomato fruit (Lycopersicom esculentum c.v Calji)

Maasumeh Hojhabrian*, Abdol-Karim Ejraei and Behnam Behrooznam

Department of Horticulture, Islamic Azad University of Jahrom, Iran.

***Corresponding author*:** Maasumeh Hojhabrian

ABSTRACT: In order to evaluate the effect of soil pH and phosphorous element on growth and yield of tomato plant (*Lycopersicom esculentum* c.v Calji) in soil culturing, was conducted an experiment as factorial arrangement in completely randomized design with three replications. The first factor was including different soil pHs (6, 7, 8) and the second factor was consisting phosphorous fertilizer (0, 40 and 80 mg P Kg^{-1} soil) in the form triple super phosphate. To provide nitrogen, 200 $mgKg^{-1}$ urea was equally used to the plants. Then the traits of flower number, fruit number, plant yield, vitamin C, and TSS and chlorophyll index were recorded. Results indicated that the highest flower number was observed in pH=6.0 and P0 treatment and the lowest in pH=8.0 and P0 treatment. The greatest fruit number was in pH=6.0 and P0 or P40 and the least in pH=8.0 and P0 treatment. The highest chlorophyll amount obtained in pH=8.0 and P40 and the lowest in pH=6.0 and P0 or P40. Generally, application of 40 mg P Kg-1 soil than P0 and P80 had the best influence on the evaluated characteristics. Therefore in the conditions of this experiment, utilization of 40 mg P Kg^{-1} soil in pH=8.0 or pH=7.0 could improved the quantitative and qualitative traits of tomato plant and fruit.

***Keywords*:** Soil pH, Phosphorous, Tomato.

INTRODUCTION

Tomato (*Lycopersicom esculentum* L.) is one of the flowering higher plants from dicotyledonous order and Solanaceae family. This plant is native to Central and South America, which during the Spanish colonial period were transferred to other parts of the world (Peivast, 2006). Nowadays, different type of this plant is grown throughout the world. Tomato is rich in vitamin C and Lycopene. Like other plants, tomatoes require nutrient elements such as phosphorus (P) and potassium (K). However, available P and K amounts will vary depending on soil pH (Daneshvar, 2000). Amount of total P in the surface level of mineral soils is 200-1000 $mgKg^{-1}$. Solubility of P in the calcareous as well acidic soils is low. Phosphorus is critical to most of the metabolic processes that occur within a tomato plant, including respiration, photosynthesis, and protein synthesis. Phosphorus is also critical in tomato plant growth due to its role in the process of moving water into the cells of developing fruit. Phosphorus is essential for juicy tomatoes. Phosphorus is sensitive to soil pH, and is most available to your plants with a soil pH of 6.0–6.5. Phosphorus deficiency is visible in tomato plants as stunted spindly growth, delayed maturity, leaves dark in color, poorly developed root systems, plants are late in setting fruit, fruit is slow to ripen, seeds are smaller in size than usual, leaf undersides are reddish in color, slender fibrous stems, and small leaves (Melendez, 2012). P uptake is an active uptake. Phosphate concentration in the root is about 100-1000 times the concentration of phosphate in the soil solution. Small part of P also is converting to organic compounds in the plant that are consisting: phospholipids, phosphorous sugar, DNA, ADP and ATP, which are energy carrier. Phosphorous led to roots growth. Phosphorous is causing to early ripening and enhancement of generative growth and in the fruit trees is leading to fruit early ripening and improvement of fruits and vegetables quality (Rajaei, 2010). pH is one of the other effective factors for uptake of nutrient elements, which it is acidity and alkalinity index in plant culture medium and is effective on soil chemical, physical and biological properties (Malakouti, 1996). The best soil pH adaptation for tomato is 6.5-7.5 (Cox and Koenig, 2010). According to the FAO statistics, Iran is the fifth producer, in the level under cultivation ranking is in the sixth class and in the yield in hectare ranking is in the thirty-eight class (FAO, 2011). Haller and Sutton, (1973) in evaluation the effect of pH and high phosphorous concentrations on growth of Waterhyacinth (Eichornia crassipes) found that maximum growth of Waterhyacinth occurred in acid (pH 4.0) to slightly alkaline (pH 8.0) water. Under high levels of phosphorous fertilization, Waterhyacinth plants exhibited luxury consumption of phosphorous. Maximum growth of Waterhyacinth occurred in water with a phosphorous concentration of 20 ppm. As the phosphorous content of the water was increased from 0 to 40 ppm, Waterhyacinth plants absorbed greater amounts of phosphorous. Phosphorous absorbed by these plants became more uniformly distributed in the leaves, stems, and roots when the phosphorous concentration was increased in the nutrient solution. Tu and Ma, (2003) examined the effects and interactions of three factors, pH, As and P, on As hyper-accumulator Pteris vittata L. to optimize plant growth and maximize As removal from contaminated sites, especially water. They found that low pH enhanced plant uptake of P (pH5≤6.25). The fern had a relatively high biomass and P uptake at low pH/low As or high pH/high As. Their results suggested that optimum plant growth could be achieved by adjusting pH corresponding to As levels in the growth media, and maximum plant As hyper-accumulation by maintaining minimum P concentrations with medium pH5≤5.21. Mullins et al, (2001) to evaluate the effect of seed phosphorus concentration, soil pH, and soil phosphorus status on the yield of white Lupin found that Lupin seed yields may be affected by the concentration of P in the planted seed, but only under high or optimum P fertility conditions. Soil pH had only minor effects on Lupin seed and dry matter production. At the highest rate of applied P (100 mg P kg_1), slightly higher yields were observed at the lowest pH. Results of this study suggest that low seed P concentrations should have minimal effects on the growth and production of winter-hardy white Lupin. Zahedi et al, (2010) examined the effect of P on Spinach and found that the yield increased by enhancement of soil P in the all stages but was not effective on plant P.

MATERIALS AND METHODS

In this study was evaluated the effect of phosphorous element in the various soil pH on growth and yield of tomato by using an experiment as factorial arrangement in completely randomized design in Jahrom township, Fars province. For this purpose 5-kg pots were filled by the soils with three soil pH (6.0, 7.0, 8.0) and then P treatments including 0, 40 and 80 $mgKg^{-1}$ P (P0, P40, P80) were added to the pots in the form of triple super phosphate. Two tomato seeds c.v Calji were sown in each pot and one of them were removed when the seedlings were 4-leaves and stronger seedling was kept. Then the treatments were operated and during experiment the moisture of the pots was in field capacity. To supply nitrogen was added 200 mg N Kg^{-1} soil as urea to each pot. Then the traits of flower number, fruit number, plant yield, vitamin C, TSS and chlorophyll index were recorded. The obtained data was analyzed by using MSTAT-C software and the means were compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Number of flower

Based on the results of Table 1, the highest flower number was observed in pH=6.0 and P0 to P80 (7.4, 6.4 and 7.8 flowers respectively) and the lowest in pH=8.0 and P0 (2.4 flowers). In pH=7.0 the number of flower non-significantly decreased by increasing the phosphorous level. There was no significant difference between all concentration of P in pH=8.0. In all cases, by increasing soil pH, the number of flower in various levels of P except P80 decreased. These results indicate that low pH will lead to more flowering in tomato plant, which is according to the findings of Aduayi et al, (2006) and Layegh et al, (2009).

Chlorophyll index

Results of table 1 showed that the greatest chlorophyll index was relative to pH=8.0 and different concentrations of P and the least chlorophyll content in pH=6.0 and P0 (42.0). In pH=6.0, by increasing P concentration from P40 to P80 was observed significant enhancement in chlorophyll index. In pH=7.0, chlorophyll content non-significantly increased by enhancement of P levels. In pH=8.0 was observed enhancement in chlorophyll index by increasing of P levels. In all cases, by increasing pH in different P Levels, chlorophyll index increased. P element and high pH is effective to chlorophyll storing, which this results are consistent to the findings of Gheshlaghi et al, (2004).

Number of fruit

The highest fruit number obtained in pH=8.0 and P80 (3.5 fruits) and the lowest in pH=7.0 and P0 P40, and pH=8.0 and P0 (1.2 fruits). In pH=6.0, the number of fruit significantly increased by increasing P concentration from P0 to P40 and significantly decreased by increasing P levels from P40 to P80. In pH=7.0, the number of fruit was stable by increasing P level from P0 to P40 and significantly increased by increasing P concentration from P40 to P80. In pH=8.0 the number of fruit significantly increased by increasing P levels. The number of fruit increased by increasing pH in the concentration of P80 (Table 1). According to the above results can be concluded that phosphorous fertilizers are effective to increase the number of fruits in tomato plant, which are consistent to the report of Oskooei et al, (2005).

Vitamin C

Basis on the results of table 1, the highest vitamin C was observed in pH=7.0 and P40 (50.60 mg) the lowest in pH=8.0 and P80 (35.20 mg). In the all pHs, vitamin C amount significantly increased by increasing P concentration from P0 to P40 and decreased by increasing from P40 to P80 $mgKg^{-1}$. By increasing pH from 6.0 to 7.0, vitamin C amount increased in the all P levels and decreased by increasing pH from 7.0 to 8.0. The concentration of 40 mg P Kg^{-1} soil was effective to enhancement of vitamin C in tomato fruit. It seems in each P levels, pH=7.0 is the suitable pH for increasing vitamin C amount in tomato fruit. These results are according to the findings of Rokhsar et al, (2010).

Table 1. Comparison the different treatments (pH and P) on evaluated traits

traits pH × ($mgKg^{-1}$)	Posphorous	Flower Number	Chlorophyll Index	Fruit Number	Vitamin C (mg)	TSS (%)	Total Acid (mg)	Day to Flowering
pH=6.0	P0	† 7.4^{a}	42.0^{e}	1.3^{d}	42.90^{cd}	5.16^{bc}	0.523^{bc}	35.6^{bc}
	P40	6.4^{a}	43.6^{e}	2.5^{b}	46.87^{b}	5.33^{bc}	0.554^{bc}	26.0^{cd}
	P80	7.8^{a}	51.4^{cd}	1.6^{cd}	41.80^{d}	5.25^{bc}	0.646^{b}	36.3^{b}
pH=7.0	P0	4.4^{b}	47.7^{de}	1.2^{d}	44.73^{bcd}	5.00^{c}	0.462^{c}	29.3^{bcd}
	P40	4.2^{b}	52.2^{cd}	1.2^{d}	50.60^{a}	5.00^{c}	0.600^{b}	27.0^{bcd}
	P80	3.2^{bc}	52.6^{cd}	2.5^{b}	46.20^{bc}	5.33^{bc}	0.615^{b}	25.3^{d}
pH=8.0	P0	2.4^{c}	58.0^{bc}	1.2^{d}	37.40^{e}	5.00^{c}	0.462^{c}	28.3^{bcd}
	P40	3.0^{bc}	60.4^{ab}	2.0^{bc}	41.06^{d}	5.50^{b}	0.646^{b}	64.8^{a}
	P80	3.9^{bc}	67.5^{a}	3.5^{a}	35.20^{e}	6.16^{a}	1.108^{a}	28.0^{bcd}

† The means in each column with similar letter are not significantly difference ($p<0.05$) according to Duncan's multiple range test (DMRT)

TSS

The highest total soluble solid was observed in pH=8.0 and P80 $mgKg^{-1}$ soil (6.16%) and the lowest in pH=7.0 and P0 and P40 as well as pH=8.0 and P0 (5.00%). In pH=6.0 and pH=7.0 was not observed any significant difference between different concentrations of P in relation to TSS. In pH=8.0, TSS significantly increased by increasing P levels. TSS increased by increasing pH in concentration of 80 mg P Kg^{-1} (Table 1).

Total acid (TA)

Regards to the results of table 1, the greatest TA was observed in pH=8.0 and P80 (1.108 mg) and the least in pH=7.0 or 8.0 and P0 (0.462 mg). In pH=6.0, TA non-significantly increased by enhancement of P concentration. In pH=7.0, TA significantly increased by enhancement of P concentration from P0 to P40. In pH=8.0, TA significantly increased by enhancement of P level. TA increased by increasing pH in P40. These results are not consistent to the findings of Rokhsar et al, (2010).

Number of day to flowering

The lowest day to flowering was observed in pH=7.0 and P80 (25.3 days) and the highest in pH=8.0 and P40 (64.8 days). In pH=6.0, by enhancement of P from P0 to P40 the number of day to flowering non-significantly decreased and from P40 to P80 significantly increased. In pH=7.0, the number of day to flowering non-significantly decreased by increasing P level. In pH=8.0, by enhancement of P from P0 to P40 the number of day to flowering significantly increased and from P40 to P80 significantly decreased. By increasing pH in medium without P, the number of day to flowering decreased and in the medium containing 40 mg P Kg^{-1} soil increased. In P80, by enhancement of pH, the number of day to flowering decreased. Above results is not according to the findings of Layegh et al, (2009).

CONCULSION

Reduction of pH (pH=6.0) caused to increasing flower production and trend of tomato plant to generative growth. On the other hand, enhancement of pH (pH=8.0) led to increasing chlorophyll index that is one of the vegetative growth indexes. The greatest fruit produced in pH=8. Regards to in pH=8.0 produced more chlorophyll in the plant; it seems the high nutrient saved had been caused to production of fruit in this pH. In contrast, deficit resources of carbohydrate production (chlorophyll) in the grown plants in pH=6.0, despite production of more flower, prevented to proper fruit set in this pH. Growing the tomato plants in pH=7.0 caused to increasing vitamin C amount compared to other pHs. TSS enhancement in pH=8.0 indicated that more carbohydrate produced in the grown plants in this pH. In spite production of more fruit in pH=8.0 but this production delayed. In fact, pH enhancement in addition to increasing fruit production led to late production of tomato crop. Attentive to the total results can be concluded that application of 40 mg P Kg^{-1} soil than P0 and P80 had the best influence on the evaluated characteristics. Therefore in the conditions of this experiment, utilization of 40 mg P Kg^{-1} soil in pH=8.0 or pH=7.0 could improved the quantitative and qualitative traits of tomato plant and fruit.

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