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Study the Effects of Micro-nutrients, Macro-nutrients and Plant Shading on Quantitative Traits of Tomato(*Lycopersicon esculentum*)

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ABSTRACT

Tomato is one of the great importance in terms of the worldwide consumption of nutritional regimes. The present study investigated the effects of macro (75, 150 and 300 kg NPK ha^{-1}) and micro-nutrients (0 zinc and 0 boron, 2 Zn and 2 B and 4 Zn and 4 B kg ha^{-1}) with plant shading (shading and non-shading) in tomato cropping systems. The results showed that application of 150 kg NPK ha^{-1} with shading produced 43.11 g fruit weight per plant and the lowest fruit weight (5.66 gr fruit weight per plant) obtained in 75 kg NPK ha^{-1}. The combination of micronutrients and macronutrients with shading had significant effects on plant height. Among studied treatments just micronutrients significantly affected brix index. Highest plant height obtained at 150kg/ha NPK and also 4kg/ha Zn and B resulted to highest plant height. The results obtained from this experiment strongly support this idea of improving the growth and yield of tomatoes by provision of balanced amount of nutrients.

***Keywords**:* Essential nutrients, Shading, Tomato, Zinc

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is one of the most popular and widely grown vegetables ranking second in importance with potato in many countries. Its uses in various forms both fresh and processed, played a major role in its wide spread adoption. Tomato is native to South America (Bibi *et al*., 2012).

Growth and yield of crops are related to the amount of solar radiation received during the growing period (Challa and Bakker, 1998). For the tomato crop, a theoretical light use efficiency of 1.0 g dry mass MJ-1 of global radiation outside the greenhouse was calculated, which equals 3.1 g dry mass MJ-1 of photosynthetically active radiation (PAR) inside the

greenhouse (Sandri *et al.,* 2003). Tomato requires a stable warm temperature for good yield with 26-30 ºC and plenty of light (Taleb and Mazen, 2015), but it grown widely through the world using not only field but also protected farmland, light is considered to be the most important environmental factor for growth and development, especially in protected farmland (Hashem *et al.,* 2011). In hot climates, shade can be applied over a greenhouse to improve fruit quality, increase fruit set and yield. However, in climates with more moderate temperatures, shade typically reduces yield of vegetable grown in a greenhouse (Yang *et al*., 2012). Shading a greenhouse may have a time dependent effect on fruit production and water and nutrient uptake in plants; after 6 weeks of shading applications, yield was reduced by 30% compare to no shade treatments (Siwek *et al*., 2010). Shaded plants had greater leaf area, although less vegetative biomass and lowers dry matter than non-shaded plants (Taleb and Mazen, 2015).

Balanced nutrition is always a prerequisite for improved growth, yield and quality of tomato crop. Nutrients can be applied either by conventional methods or by foliar application. Major advantage of nutrients (macro/micro nutrients) applied through foliar feeding are instantly available to plants (Ganjineh *et al.,* 2019). This property of foliar feeding makes this method better than others. An important practice in tomato production is the use of a micro and macro nutrients, a mild solution in the water used around each plant at transplanting (Ejaz *et al.,* 2011).

Higher yield per unit area can be achieved by improving modern cultural practices with better macro and micronutrient management. Optimum use of fertilizers, their type and method of application play an important role in sustainable crop production. Microelements are defined substances that are crucial for crop growth; however, they are used in lower amounts as compared to macronutrients, such as N, P and K (Bahrani, 2015; Maleki, *et al*., 2014). Gul *et al.* (2011) claimed that profitability of micronutrients will be obtained in combination with macro elements, such as nitrogen and potassium. Application of foliar fertilizing in agriculture has been a popular practice with farmers since the 1950s, when it was learned that foliar fertilization was effective and economic (Omidi *et al.,* 2011; Mirzakarami *et al*., 2020). Recent research has shown that a small amount of nutrients, particularly Zn, Fe and Mn applied by foliar spraying increases significantly the yield of crops (Bahrani, 2015; Mirzaei Heydari *et al*., 2019). Narimani *et al.* (2010) reported that microelements foliar application improve the effectiveness of macronutrients Therefore, the objective of this study was to study the effect of combination of micro- and macro-nutrients for increasing yield and yield parameters of tomato in the presence of plant shading.

MATERIALS AND METHODS

The studies were conducted in a field area in west of Iran, at the Islamic Azad University , Ilam Branch ,Ilam ,Iran at Kermanshah Research Station, Iran. (31°58´ N, 45°24´ E and 1387 m above the sea level) during 2012-2013. The experiment was split-plot on the basis of complete randomized block design, with three replications. Treatments were consisted of three levels of macronutrients from Beyhagh Roshd Company (K1: 150kg/ha NPK according

to fertilizer recommendation, K2: 75 kg/ha NPK and K3: 300 kg/ha NPK) as first factor, three levels of micronutrients (M0: without zinc and boron, M1: 2 kg/ha Zn and 2 kg/ha B and M2: 2 kg/ha Zn and 2 kg/ha B) as second factor and two levels of shading as third factor including non-shading (S0) and shading (S1). Micronutrient foliar application was done at two times, one time when plants had 6 or 8 leaves and another when they have 10 or 12 leaves (early of flowering stage). The cultivar used in this experiment was Ciliegia) Vilmorin Co., France). At maturity, 10 plants were taken randomly from each subplot for recording the following morphological, yield components and yield. The various parameters within the rapeseed plant that are discussed in this paper were evaluated as follows: fruit number per harvest, fruit weight, plant height, fruit size. Brix index (total soluble sugars in fruit dry matter) was measured by digital refracto-meter (PAL ALFA, Japan). Samples were dried in a forced-air oven at 70 0 C for 48 h. Data were analyzed by analysis of variance by SAS software (SAS, 2009). When significant differences were found (P=0.05) among means, Duncan's multiple range test (DMRT) were applied.

RESULTS AND DISCUSSIONES

Fruit number and weight per plant

Table 1 shows the results of analysis of variance (AVOVA) of the effects of studied treatments on some of yield parameters of tomato. According to results main effects of macronutrients (K) were significant on fruit number (P<0.01) and other treatments had no significant effects on fruit number per plant. While main effects of shading, macronutrients and micronutrients and interactions of shading and macronutrients significantly affected fruit weight (P<0.05, Table 1).

Mean comparison results showed that application of 150 kg/ha NPK resulted to harvesting of 53 fruits per harvest. Lowest fruit numbers in all harvesting obtained in 75 kg/ha NPK by 44.1 fruits which had significant difference with other macronutrients treatments (Table 2). Also, results showed that 150 kg/ha NPK application had 43.11 g fruit weight per plant and lowest fruit weight obtained in 75kg/ha by 5.66 gr. However application of 4kg/ha Zn and 4 kg/ha B resulted to fruit weight of 7.09 which showed considerable increase compared to micronutrients control. Fruit weight in shading treatment obtained as 6.89gr which had no significant difference with non-shading treatment (6.09gr, Table 2). Interaction of shading and macronutrients also affect fruit weight and 150 kg/ha NPK and shading treatment resulted to 7.9 gr fruit weight (Figure 1)

Results showed that there is an increase in the number of fruits in the shaded plants, in compare to non-shaded ones, which may be due to shading cause an increase in uptake of water and nutrients due lower transpiration (Taleb and Mazen, 2015).

Puri *et al*. (1999) reported that the combine NPK improved the oil content of canola. Zn is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes (Ghasemian *et al.,* 2010).

Application of Zn or Fe has been reported significant positive effects, in most cases, on growth measurements and chemical composition (Ghasemian *et al*., 2010; Bahrani, 2015).

Table 1. results of analysis of variance of effect of micro- and macro-nutrients and shading on some of yield parameters of Tomato

Fruit size	Flower No./plant	Brix index	Plant height	Fruit weight	Fruit number per harvest	Df	SOV
0.20ns	0.11ns	3.5*	21.1ns	4.55**	21.43ns	2	Replication
3.11*	0.35ns	1.24ns	385.1**	8.54**	53.63ns	1	Shading (S)
0.36ns	2.93**	0.90ns	570.1**	10.01**	369.88**	2	Macronutrients (K)
0.56**	0.95**	4.02*	66.46**	6.51**	17.88ns	2	Micronutrients (M)
0.67*	0.21**	2.69ns	11.11*	4.99**	11.08ns	2	S×K
0.02ns	0.03ns	0.62ns	6.37*	0.13ns	1.26ns	2	S×M
0.08ns	0.17**	0.37ns	23.73**	0.31ns	10.80ns	4	M×K
0.11ns	0.01ns	0.01ns	0.65ns	0.04ns	7.22ns	4	S×M×K
0.07	0.02	0.56	1.40	0.27	8.67	24	Error
7.8	2.5	10.27	4.42	8.14	6.0	-	CV (%)

*, ** and ns show significant differences at 5 percent and one percent probability level and non-significant differences, respectively.

Table 2. mean comparison results of effect of micro- and macro-nutrients and shading on fruit number per harvest and fruit weigh of tomato

Treatments								
Shading		Micronutrients			Macronutrients			
S1	S0	M2	M1	M0	K3	K2	K1	
50.0a	48.0a	49.8a	49.4a	47.9b	44.1c	53.0a	50.0b	Fruit number
6.89a	6.09a	7.09a	6.49b	5.88c	5.66c	7.11a	6.69b	Fruit weight (gr)

Rows having similar letters have no significant difference at 5% probability level.

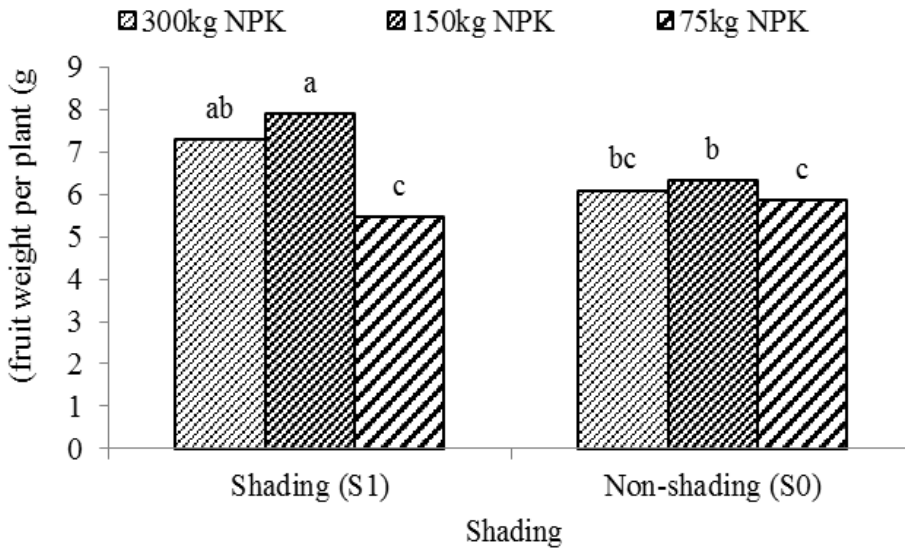

Figure 1. Interaction effect of macronutrients and shading on tomato plant fruit weight

Similar letters indicating non-significant differences.

Plant height and Brix index

Results showed that main effects of macro and micronutrients and shading and interaction of micro and macro nutrients, shading and macronutrients had significant effects of plant height (Table 1). Among studied treatments just micronutrients significantly affected brix index ($P<0.05$, Table 1). Highest plant height obtained at 150kg/ha NPK and also 4kg/ha Zn and B resulted to highest plant height. Shading increased plant height by 7 percent compared to non-shading treatment (Table 3). Highest plant height obtained in 150kg/ha NPK and 4kg/ha micronutrients (Zn+B) by 33.9 cm which had significant differences with other treatments. Lowest plant height obtained in micronutrients control treatment and 75kg/ha NPK application (Figure 2). According to results 4kg/ha Zn and 4kg/ha B obtained highest brix index (7.83). Lowest brix index obtained in non-application of Zn and B by 6.89 (Figure 3). Results are in consistent with Bibi *et al.* (2012) and Ejaz *et al.* (2011) findings. This enhancement in growth and yield is due to availability of nutrients (N, B and Zn) and ease of absorbing them which fulfill the nutritional requirements of plant. These results have also been supported by the work of (Ejaz *et al.*, 2011; Tariq and Mott, 2007).

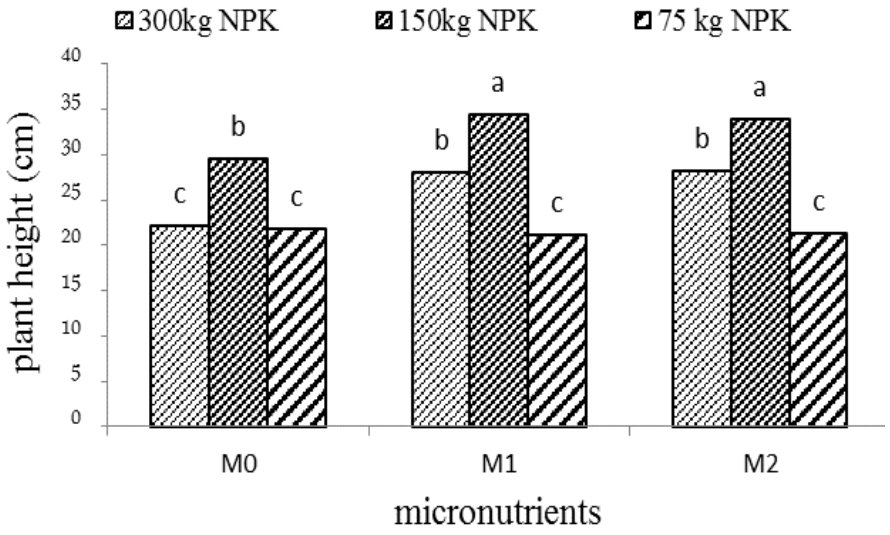

Figure 2. Interaction effect of micro and macronutrients on tomato plant height

Similar letters indicate non-significant differences.

Table 3. mean comparison results of effect of micro- and macro-nutrients and shading on flower number per plant and fruit size and height of tomato

Fruit size (cm)	Flower number/plant	Plant height (cm)		
3.58a	5.7b	26.2b	K1	
3.69a	5.3c	32.7a	K2	Macronutrients
3.41a	6.1a	21.4c	K3	
3.4c	5.5c	24.5b	M0	
3.5b	5.8b	27.9a	M1	Micronutrients
3.7a	6.0a	27.8a	M2	
3.7a	5.8a	29.4a	S0	Shading
3.4b	5.7a	27.1b	S1	

Rows having similar letters have no significant difference at 5% probability level.

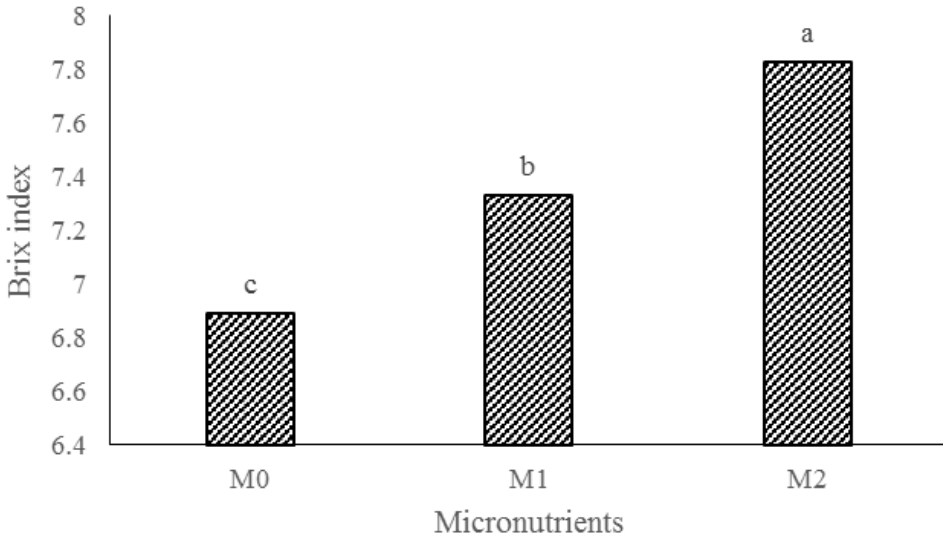

Figure 3. Mean comparison results of effect of micro-nutrients on Brix index of tomato

Similar letters indicate non-significant differences.

Flower number and fruit size

According to results of Table 1, treatments had significant effects on flower number per plant including micro and macronutrients, and interactions of M×K, M×K× ($P<0.01$). Tomato fruit size affected by shading and interaction of shading and macronutrients treatments (Table 1). According to results, 300kg/ha NPK and 75kg/ha NPK had highest and lowest flower number per plant, respectively, by 6.16 and 5.79. Also M2 micronutrients treatment resulted to 5.98 flower number which had significant differences with other treatments (Table 3). M2 treatment increased fruit size compared to other treatments by 3.75cm. In shading treatment, fruit size obtained as 3.70cm which had significant difference with non-shading treatment by 3.42cm (Table 3). Paez and Lopez (2000) reported that shading contributed to ameliorate the effect on vegetative growth probably by causing a decrease in temperature but did not alter fruit establishment. Thangam and thamburaj (2008) stated that the number of fruits per plant was more in open field than under shade. Bibi *et al.* (2012) showed that partial shading increased tomato fruits per plant and found that Fruit size was not affected significantly by shade.

CONCLUSION

Results showed that macro- and micro-nutrients and plant shading significantly affected plant growth. Shading increased plant growth and yield parameters, so shading tomato during summer is recommended. Also applying micro nutrients increased plant growth. The deficiencies of N, B and Zn is hampering the crops yield worldwide so the provision of these critical nutrients to tomato crop not only fulfill the plant nutrient requirement but also help in increasing the growth and yield of tomato plants. The results obtained from our experiment

strongly support this idea of improving the growth and yield of tomatoes by provision of balanced amount of nutrients.

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