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ORIGINAL PAPER

EFFECTS OF TWO DIFFERENT LIGHT INTENSITIES ON PLANT GROWTH, ION UPTAKE AND DISTRIBUTION IN TOMATO PLANTS*

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Absract

This study was carried out to determine relationships between light intensity and nutrient elements by examining the growth parameters, ion uptake and distribution between plant organs of tomato plants under controlled conditions. In the study, seedlings of an indeterminate Adamset F1 hybrid tomato variety were used. The seedlings were grown by applying two different light intensities: 400 µmol m^{-1} s^{-1}, which is the optimum light intensity for tomatoes, and 800 µmol m^{-1} s^{-1}, which is twice the optimum light intensity. In this study, LED lamps, which emit light close to sunlight, were used as the light source. Sampling for measurement and analysis was done on the 40th day of the application. The Hoagland nutrient solution was replenished every week. Leaf weight, leaf number, stem weight, stem length, internode distance, stem thickness and root weight of the plants taken on the 40th day were measured. Concentrations of macro- and micronutrients (N, P, K, Ca, Mg, Fe, Mn, Zn, Cu) in the root, stem and leaf samples of plants were also measured. The root, stem and leaf weights of the plants that were treated with two different light intensities were found to be different. The highest root, stem and leaf weights were observed in plants with high light exposure. It has been found that light intensity is effective in stimulating the ion uptake and distribution, and especially the amount of microelements in all three organs of tomato plants analyzed, and there was higher uptake under high light application compared to optimum light application.

Keywords: chemical composition, macronutrients, micronutrients.

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INTRODUCTION

Among the main environmental factors, the most important one, regulating photosynthesis and thus plant survival, growth and adaptation, is solar radiation. Light intensity for any plant species varies temporally (seasonally and daily) and spatially. Therefore, plants develop acclimatization and plasticity to cope with changing light regimes (Zhang et al. 2003). Most plant species have the ability to develop anatomical, morphological, physiological, and biochemical changes in response to different light intensities (Sousa Paiva et al. 2003, De Carvalho Goncalves et al. 2005). Based on previous comparative studies, biomass of roots, stems, leaves and whole plant, as well as the rate of photosynthesis, transpiration and stomatal conductivity of water vapor decreased under low light (An, Shangguan 2009, Wang et al. 2009, Mielke, Schaffer 2010). Conversely, there are studies where plant height increased under low light intensity (Yang et al. 2007, Wang et al. 2009). Also, plant leaves expanding under high irradiance had a lower photosynthetic pigment content than leaves expanding under low irradiance (Czeczuga 1987, Adamson et al. 1991, Yang et al. 2007, Mielke, Schaffer 2010).

Physiological and morphological changes in the process from seed germination to fruit maturity in plant production are defined as plant development. Light intensity, duration of light and type of light have very important effects on the growth and development of plants (Taız, Zaıger 2008). Therefore, while it is known that light intensity directly affects the rate of photosynthesis, it also indirectly affects plant growth and development. In addition, it has been determined that the leaf areas expand when the plant is exposed to low light and high temperature stress, and it has a positive relationship with temperature (Ozkaplan, Balkaya 2019, 2020, Taiz, Zaiger 2008). Most plant species have the ability to develop anatomical, morphological, physiological, and biochemical changes in response to different light intensities (Sousa Paiva et al. 2003, De Carvalho Goncalves et al. 2005). Also, plant leaves expanding under high irradiance had a lower photosynthetic pigment content than leaves expanding under low irradiation (Mielke, Schaffer 2010).

Plants need 16 essential elements for growth and development. Of these, carbon (C), hydrogen (H) and oxygen (O) are obtained from air and water, while the remaining elements are obtained from the soil through roots (Bouain et al. 2019). Among them, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) are considered macronutrients due to the large amounts of these elements needed by plants. Given that these nutrients are essential for the plant life cycle, plants have developed a number of mechanisms to better absorb and utilize ions (Chen et al. 2015, Wang et al. 2016, Pan et al. 2019, Zhang et al. 2019, Wang et al. 2020). Light can greatly affect the composition of mineral elements of plants (Amoozgar et al. 2017). Because plants are grown in many environments and

under many conditions, factors that affect their mineral composition need to be considered and better understood.

From the moment the light signal reaches the plant, it takes and uses more than one nutrient according to the intensity, angle and color of the light, and other ecological conditions. In all these processes, light, as an indispensable source of energy, shows great variation with time, seasons and circadian clock drift (Sakuraba, Yanagisawa 2018). A number of studies show that nutrient absorption and use by plants are altered by light quality, intensity, and photoperiod. In particular, light can change the uptake of more than one element with changes in light quantity and quality. In addition, studies reveal links between light perception and food intake (Zhai et al. 2019, Lin et al. 2020).

LED lamps were used in this study. The reason why LED lamps are preferred is that they emit light close to sunlight, generate heat and have low energy consumption. Our aim was to determine the relationship between light intensity and uptake of nutrients by plants. To this aim, we examined the growth parameters of plants, ion uptake and their distribution between plant organs in cases where there is less or more light. This was expected to create the ground for recommendations how to eliminate the problems that occur in plant growing. Our aim was to illuminate the relationship between light and nutrient elements in tomato plants exposed to two different light intensities and grown under controlled conditions. To this aim, we determined the distribution of some nutrients in roots, stems and leaves as well as the total weight of the plants.

MATERIAL AND METHOD

Plant material and growing conditions

This study was carried out in a split, air-conditioned climate room with normal atmosphere. In this study, which was carried out to determine the morphological and physiological changes caused by two different light intensities, an indeterminate tomato variety called Adamset F1 was used as the plant material, and LED lamps were used as the light source.

In the study, tomato seeds were first watered with tap water after 100 seeds were planted in plastic germination cups filled with pumice. After the pumice was thoroughly wetted and the excess irrigation water was drained, the germination pots were placed in the climate chamber with a temp. of 25°C and a humidity of 70%, and watering was continued with tap water little by little so that the pumice would not dry out. When the cotyledon leaves became horizontal and true leaves began to appear, irrigation was continued with Hoagland nutrient solution (Hoagland, Arnon 1938). Tomato seedlings with 2nd true leaves were taken into water culture in 25x25x18 cm

plastic tubs filled with Hoagland nutrient solution from the pumice medium. Tomato seedlings were placed on specially prepared perforated plastic trays by wrapping them with small pieces of sponge. The experiment was set up with three replications and with 20 plants in each replication. The plants were placed with their roots in the nutrient solution, and the solution was aerated with an aquarium air pump with 220V/50Hz voltage (Table 1). The seedlings grown in Hoagland nutrient solution (pH 5.8) were grown under two different light intensities: 400 μmol m^{-1} s^{-1}, which is the optimum light intensity for tomato (Ozkaplan, Balkaya 2019), and 800 μmol m^{-1} s^{-1}, which is twice the optimum light intensity. The light source consisted of LED lamps, emitting light closest to the sunlight.

Table 1

Nutrient elements and their amounts (ppm) used in the nutrient solution

Elements	(ppm)
Nitrogen (N)	186
Phosphorus (P)	39
Potassium (K)	146
Magnesium (Mg)	25.5
Calcium (Ca)	200
Sulfur (S)	34
İron (Fe)	3.3
Manganese (Mn)	0.50
Bor(B)	0.205
Copper (Cu)	0.015
Zinc (Zn)	0.055

Determination of measurements and analyzes

Root weight (g), stem weight (g), leaf weight (g), leaf number (piece), stem length (cm) and stem diameter (mm) were measured in the plants taken for measurement and analysis.

Root, stem and leaf weight (g)

Root, stem and leaf weights were determined by weighing on a balance with a 0.001 g readability.

Number of leaves (pcs)

The leaves of the harvested plants were counted one by one.

Stem length (cm) and stem diameter (mm)

The stem length was determined by measuring the distance between the root collar of the plant and the shoot tip with a ruler. The stem diameter of the plant was measured with a caliper (mm).

Macro- and micronutrient content

The first three leaves from the tip were taken, and these samples were stored in a deep freezer at -40°C. For ion analysis, 200 mg of each leaf sample stored in the freezer were weighed, 10 ml of 0.1 N HNO_3 (nitric acid) were added, and the samples are kept in plastic boxes with lids, in the dark, at room temperature, for one week. K, Ca, Fe, Cu, Zn, Mg and Mn ions were read in an atomic absorption device according to Kacar (1994). At the end of these measurements, the amount of ions in the fresh leaf sample was determined as g mg^{-1} fresh weight (Taleisnik et al. 1997).

Nitrogen content

The leaf samples taken were dried in a digital oven at 70°C until they reached constant weight. The samples were ground in a mill and returned to the oven again for moisture absorption. Then, the samples taken from the oven were left in a desiccator and amounts of 20 mg were weighed (Kacar, Inal 2008). Nitrogen value (%) was determined with a Gerhardt Dumatherm device in the Science Application and Research Center.

Statistical analysis

In order to evaluate the research data, obtained to determine the morphological and physiological changes caused by two different light intensities in the tomato plant, variance analysis was applied in the Statgraphics statistical analysis package program. The experimental variants that were found to be statistically significant were grouped with the Duncan test at the 5% significance level.

RESULTS AND DISCUSSION

The growth parameters, ion uptake and distribution between plant organs were investigated under controlled conditions. The results are presented in Table 2.

When the growth parameters of tomato plants treated with two different light intensities were evaluated (Table 2), the difference between the root weights of plants was found to be significant. Root weights of plants were higher under the high than under the optimum light application. While the average root weight of the plants under high light intensity was 34.4 g,

Table 2

Effects of two different light intensities on plant growth parameters in tomato plant

Application	Optimum light	High light	*P* value
Root weight (g)	18.1±2.24 *b*	34.4±0.41 *a*	0.987
Stem weight(g)	32.98±6.92 *b*	41.48±7.75 *a*	0.105
Stem length (mm)	52.9±7.74 *a*	49.82±8.63 *a*	0.569
Stem diameter(mm)	7.89±1.11 *a*	8.65±0.41*a*	0.243
Number of leaves (pcs)	10.6±1.67 *a*	11.8±1.09 *a*	0.216
Leaf weight (g)	81.38±12.85 *a*	83.44±9.54 *a*	0.780

The difference between the means marked with a lowercase letter in the same row is significant ($p \leq 0.05$).

the average root weight of the plants under optimum light intensity was 18.1 g. Again, while the average stem weight of the plants under optimum light intensity was 32.98 g, the average stem weight of the plants under high light intensity was 41.48 g. It was found that there was no statistically significant difference between the applications in terms of the stem length, stem diameter, number of leaves and leaf weight. Light affects the production of metabolites by being effective in photosynthesis, which is the most basic function of substance production in plants, and can be used as an effective tool to make metabolic changes in plants, including the reduction or increase of nutrient accumulation (Liu et al. 2004). A change in the light environment towards a certain wavelength causes a physiological change in the plant exposed to light (Ouzounis et al. 2015). Thus, the effect of the light spectrum on plant physiology and metabolism is seen. Both mineral deficiencies and toxicity or excessive light intensity can reduce plant growth (Levetin, Mcmahon 2008). In our study, the more positive effect of high light intensity on photosynthesis may have increased the production of assimilates in the plant. This situation showed an increase in other metabolic activities in the plant, and the production of matter, and therefore organ development was better than under the low light intensity.

Ozkaraman (2004) stated that the root weight increased significantly in melon plants grown at high light intensity. It was determined that the application of light used at different wavelengths significantly increased many parameters (such as leaf area, shoot fresh weight and root dry weight) in seedlings. The highest plant stem diameter value was determined under high light (1500 μmol m^{-2} s^{-1}) and high temp. (30°C), and the lowest plant stem diameter was observed under low light (70 μmol m^{-2} s^{-1}) and low temp. (15°C), Demir and Cakirer (2015). Gunay (1982) stated that with the increase of light intensity, plants become stunted and increase their stem diameters. Uzun (2001) stated that there is a positive curvilinear relationship between the plant's stem diameter and temperature, and a positive linear relationship with light intensity, according to his experiments on tomato and egg-

plant. Diaz Perez (2013) concluded that low light conditions reduced the number of leaves in pepper, while McCall (1992) found that applied additional light increased the number of leaves in tomatoes. It has also been revealed by many researchers that there is less dry matter accumulation in plants grown in low light conditions (Cemek 2002, Ozkaraman 2004). The light intensity being more than desired causes oxidative stress as well as changing the hormonal balance in the plant. Different light signals can trigger plant hormones, resulting in changes in plant growth and development (De Wit et al. 2016). Light modulates many hormonal pathways, including the signaling pathways of gibberellins, abscisic acid (ABA), auxin, cytokinin (CTK), and ethylene to regulate developmental changes. Under intense light, an increase in the amount of cytokine of the green parts of plants and a decrease in the amounts of auxin and gibberellin occur. In particular, auxin moves from the apical meristems to the roots, increasing assimilate transport towards the roots and accelerating root development (Taiz, Zaiger 2008). In our study, it was observed that the growth and development of plants with high light developed better than those with low light. In fact, it was observed that the stem lengths of the plants were shortened due to high light compared to low light. The reason for this may be a decrease in the gibberellin ratio and an increase in the cytokinin ratio due to the effect of high light intensity. For this reason, there may be shorter stem lengths due to an increase in carbon hydrate accumulation.

Amounts of ion accumulation in plant organs

Ca in the organs of tomato plant grown at two different light intensities.

The amount of Ca^{+2} ion accumulation was evaluated according to the organs in plants grown under two different light intensities, the accumulation in the root and stem organs was found to be higher in the plants that were exposed to high light than to the optimum light intensity. Calcium accumulation in leaf organs was found to be statistically insignificant in both treatments. Calcium ion accumulation in leaves was higher and different compared to that in root and stem organs in both applications. Other organs were found to respond similarly.

The difference between organs in terms of potassium ion accumulation was found to be significant under high light. The highest accumulation was found in the stem; the lowest accumulation was found in the root. Under the optimum light application, similar results were obtained in roots and stems, while lower potassium accumulation occurred in leaves. Between the two light treatments, the potassium accumulation in the root was higher in the low light application, and the accumulation in the stem was found the same in both light regimes. In leaves, it was found to be higher under high light.

Also, the Mg^{+2} ion accumulation in the plant organs was evaluated, and the differences between the two light intensities were found to be significant for all organs except the root. Magnesium accumulation in the stem and

leaves was found to be higher under high light than under optimum light. The accumulation in the roots was found to be similar in the two light regimes. In both light treatments, the lowest magnesium accumulation was in the roots and the highest accumulation was in the leaves (Table 3).

Many researchers have tried to explain why macronutrients are high in plants that receive intense light, with their studies with different plant species. Barta and Tibbitts (2000) showed that Ca deficiency (tip burn) in lettuce occurs only in young leaves surrounded by the surrounding leaves and therefore not exposed to light and ambient atmosphere. The increase in Ca concentration in leaves exposed to light is faster than in closed leaves. Also, light provides energy for the absorption of elements by producing carbohydrates in plants. As the light intensity increases, plant roots accumulate enough sugar for the absorption and transport of active energy-consuming nutrients. Insufficient carbohydrate supply in roots causes inhibition of root respiration and oxidative phosphorylation (Wang 2009), decreased ATP supply and activity of Na+-K+-ATP enzyme, and reduced absorption of nutrients by roots. However, light reduces the accumulation of K, Na and Mo in the roots (Silva-Navas et al. 2015). In a study on mineral nutrition and productivity of cucumber plants in the greenhouse, three different light levels (120, 190, 240 μmol m^{-2} s^{-1}) were applied to the plants. At low light levels, the content of K and Ca was found to be high, while the content of N was found to be lower. On the other hand, some studies have shown that excessive light application reduces the positive effect on nutrient uptake. It has been stated that the utilization efficiency of Mg first increases and then decreases with the increase of light intensity (Fang 2018). Micronutrient accumulation in plants is of interest because of the possible relationship between yield and nutrient accumulation (Rasmusson, Gengenbach 1984). Atkinson (1990) reported that a plant's nutrient demand is related to its biomass production and its uptake is related to its growth rate. At this study, Ca, K and Mg total ion accumulations of plants with high light intensity were higher than those with low light intensity. The reason for these results may be that light provides energy for the absorption of elements by producing carbohydrates in plants, and as the light intensity increases, plant roots accumulate enough sugar for the absorption and transport of active energy-consuming nutrients. As biomass production increases, the demand for nutrients increases, both in total quantity and intake intensity.

The difference in the amount of nitrogen accumulated in plants under two different light intensities is statistically significant. It was found to be 4.68% under high light intensity and 5.496% under low light intensity (Table 4).

Nitrogen (N) plays an important role in the growth and development of plants. Many authors (Causin et al. 2006, Hogewoning et al. 2010, Amoozgar et al. 2017) have established a link between nitrogen uptake and photosynthesis. Nitrogen supply and allocation in plant leaves has a significant effect on ATP and photosynthetic enzymes in the photosynthesis

Table 3

Effects of two different light intensities on the amounts of Ca, K and Mg ions in tomato plant (μg mg^{-1} F.W.)

	Ca				K				Mg			
Application	root	stem	leaf	*P*	root	stem	leaf	*P*	root	stem	leaf	*P*
Optimum light	18.900*bB*	12.874*bB*	38.05*aA*	0.006	5.05*aA*	5.089*aA*	3.526*bB*	0.320	1.489*cA*	5.044*bB*	11.802*aB*	0.000
High light	22.334*bA*	27.808*bA*	37.170*aA*	0.016	3.337*cB*	5.748*aA*	4.733*bA*	0.034	1.044*cA*	8.107*bA*	13.322*aA*	0.000
P value	0.514	0.034	0.823		0.264	0.445	0.005		0.121	0.035	0.330	

Small letters in the same row indicate the differences between the organs ($p \leq 0.05$).
Capital letters in the same column indicate the difference between the same organs ($p \leq 0.05$).

Table 4

Effects of two different light intensities on the amount of nitrogen ions in tomato plants (%)

Application	Nitrogen (%)
Optimum light	4.685±0.401*aB*
High light	5.496±0.985*aA*
P value	0.0476

The difference between means marked with lowercase letters in the same column is significant ($p \leq 0.05$)

process. Most plants experience a decrease in the rate of photosynthesis due to severe N deficiency (Mu and Chen 2020). Therefore, a high rate of photosynthesis can increase the nitrogen uptake in plants.

The Fe and Mn ion accumulation in the root, stem and leaf organs of tomato plants grown under two different light intensities was determined, and the data are given in Table 5.

Table 5

Effects of two different light intensities on the amount of Fe and Mn ions in tomato plants (μg mg^{-1} F.W.)

Application	Fe				Mn			
	root	stem	leaf	*P* value	root	stem	leaf	*P* value
Optimum light	5.195*bA*	0.729*cB*	15.243*aA*	0.000	6.535*cA*	8.619*bA*	20.363*aA*	0.012
High light	2.955*bB*	1.516*cA*	14.254*aB*	0.000	2.744*cB*	5.986*bB*	10.251*aB*	0.000
P value	0.2405	0.0716	0.6727		0.0502	0.4712	0.0097	

Lowercase letters in the same row indicate differences between the organs ($p \leq 0.05$). Capital letters in the same column indicate differences between the applications ($p \leq 0.05$).

It was observed that there were differences in the iron accumulation in the roots, stems and leaves of the plants that were applied two different light intensities. Higher iron was found in plants exposed to optimum light than those treated with high light. The amount of Fe ion accumulation was evaluated in plants grown under two different light intensities, it was observed that there were statistically significant differences between the applications according to the organs. Again, there were differences between the organs in terms of Fe ion accumulation in both light treatments. The highest Fe accumulation was in the leaf, the lowest Fe accumulation was in the stem. Fe element plays a fundamental role in the photosynthetic electron transport chain (ETC) and therefore the conversion of light energy to organic carbon products (Raven et al. 1999, Yuruela 2013). Shı et al. (2006) the Fe content in the leaves was significantly higher under low light intensity than under optimum light intensity. In Qiao (2007)'s study, Fe first increase in intense light and then decrease with decreasing light intensity.

Excess Mn significantly decreased the Fe content in the leaves, especially under optimum light intensity. The decrease in the contents of Mg and Fe may increase the sensitivity to light intensity (Cakmak, Marschner 1992, Cakmak et al. 1998). In our study, it is seen that there is a decrease in leaf Fe content at high light intensity.

The results were evaluated in terms of Mn ion in the study, significant differences were found between the applications according to all three organs. The Mn accumulation in the roots, stems and leaves of the plants exposed to high light was found to be significantly higher than the optimum light application. Again, in both light treatments, the highest rate of Mn accumulation was found in the leaves, while the lowest level was found in the roots.

The most important task of manganese in green plants is its role in the photosynthetic oxygen cycle. All plants need manganese for the oxygen cycle and the breakdown of water in the photosynthetic system. The first event that occurs in manganese deficiency is the interruption of the luminous reactions in the electron transport chain. In this case, photophosphorylation reactions are also adversely affected, resulting in a decrease in photosynthesis and fragmentation in chloroplasts. Manganese is an activator of some enzymes, and it is necessary for the stability of the chloroplast membrane and for the release of oxygen in photosynthesis (Taiz, Zaiger 2008). It is suggested that the occurrence of Mn toxicity in plants is closely related to light intensity. Reduction of light intensity attenuated the toxic symptoms of tobacco under high manganese stress and decreased the extent of photosynthetic rate reduction (Nable et al. 1988). At high levels of Mn in nutrient solution, the increase in light intensity increased the Mn uptake by the plant and resulted in a decrease in the chlorophyll content of the leaves. Even at similar levels of Mn concentrations within the leaves, high light intensity increased the severity of Mn induced chlorosis (Horiguchi 1988, Rayen et al. 2012). Most of the evidence collected to date shows that light intensity has a profound effect on ion uptake in plants. In our study, the plant growth of the plants that were applied intense light was higher than the low light. Plants need more micronutrients when they find an intensive growth environment and show rapid growth. However, since the Mn nutrient element is located in the photosynthesis system of the plant, it is understood from the results we have obtained and the studies that other researchers have done with different plant species that they need more of it.

The accumulation of Cu ions in the plants exposed to two different light intensities was determined. The amount of Cu accumulated in leaves of the plants grown under high light intensity was lower than in leaves of the plants which were supplied the optimum light intensity (Table 6). The Cu accumulation in the other organs was found to be the same in both light treatments.

While the Zn accumulation in the roots, stems and leaves of the plants was higher in the optimum than in the high light application variant, there

Table 6

Cu and Zn ion accumulation in the root, stem and leaf organs of tomato plants under two different light intensities (μg mg^{-1} F.W.)

Application	Cu				Zn			
	root	stem	leaf	*P* value	root	stem	leaf	*P* value
Optimum light	1.754*aA*	0.081*bA*	1.419*aA*	0.0143	8.235*aA*	4.007*bA*	5.781*aA*	0.328
High light	1.573*aA*	0.073*bA*	0.842*abB*	0.0547	4.345*bB*	3.081*bB*	3.729*bB*	0.070
P value	0.765	0.0721	0.0332		0.0153	0.0362	0.0200	

Lowercase letters in the same row indicate differences between the organs ($p \leq 0.05$). Capital letters in the same column indicate differences in the organs between the treatments ($p \leq 0.05$).

was no statistical difference between the organs in either of the light intensity regimes (Table 6).

Baligar et al (2006) applied two different light intensities in the cultivation of nine different tropical legume plant species, and the concentrations of almost all micronutrients were high at low light intensity (200 μmol m^{-2} s^{-1}) and low at high light intensity (400 μmol m^{-2} s^{-1}). Only Cu concentrations tended to increase with the increasing PPFD. Qiao (2007) demonstrated that the relative content of most elements in dried tobacco leaves increased with decreasing light but light intensity had different effects on different elements even in the same variety. Again, according to the same researcher, the P, Cu and Zn content of tobacco plant increased with the decrease of light intensity, unlike the K, Cl, N, Ca content, which decreased. Mg, Mn and Fe under intense light first increased and then decreased as the light intensity was decreased (Qiao 2007). Therefore, light intensity is likely to modulate the intake and utilization of nutrients through various regulatory mechanisms. The decrease in most of the micronutrient concentrations in plants grown under higher light intensity is probably related to the higher proportion of soluble dry matter formed in the plant exposed to low light. Such an effect is known as the dilution factor in mineral nutrition. General microelement concentrations are likely to appear as Mn > Fe > Zn > B > Cu (Jarrell, Beverly 1981).

When we evaluate the results of our study, we may conclude that plants have lower microelement accumulation at high light intensity because of the dilution factor due to the higher growth of plants under higher light intensity. It may also be possible that light intensity modulates the intake and utilization of nutrients through various regulatory mechanisms. The general micronutrient accumulation pattern in our current study was found as Mn > Fe > Zn > Cu.

CONCLUSIONS

1. It was found that two different light intensities (400 and 800 μmol m^{-1} s^{-1}) affected the uptake and distribution of macro- and micronutrients between the growth parameters (root, stem and leaf) and organs of tomato plants. It is thought this was due to the fact that the different light regimes altered the hormonal activity.

2. In addition, it is understood from the results obtained from our study that more nutrients are needed in the photosynthesis system under intense light due to the high photosynthetic activity in the plant.

3. It is understood that light affects metabolite production by being effective in photosynthesis, which is the most basic function of substance production in plants, and that it can be used as an effective tool to make metabolic changes in plants, including reducing or increasing nutrient accumulation. It can also be concluded that the balance of nutrients should be adjusted according to the light intensity.

4. Tomato plants can be grown under light intensities between 400 and 800 μmol m^{-1} s^{-1}. However, it was observed that the need for micronutrients increased as the light intensity increased.

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