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Full Length Research Paper

Uptake of calcium nitrate and potassium phosphate from foliar fertilization by tomato

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The spectrum of materials known to be absorbed by plant foliage has become exceedingly broad. To determine, the effect of different levels of nitrogen and potassium solution on the yield and quality of tomato, a two factor completely randomized experimental design (CRD) with three replications was conducted with `Maha` cultivar in an unheated plastic tunnel. Nitrogen and potassium solution from the source calcium nitrate and potassium phosphate were used with an amount of 4, 6 and 8 and 2, 4 and 6 mmolL^{-1} respectively. Results of presented experiment revealed different effects of calcium nitrate and potassium phosphate as foliar nutrition and the interaction of these fertilizers on the yield and quality of tomato. The results of this experiment demonstrated that tomato crops fertilized with 6 mmolL^{-1} calcium nitrate and 4 mmolL^{-1} potassium phosphate contained greater quality.

Key words: Nitrogen, potassium, foliar nutrition, yield, quality, tomato.

INTRODUCTION

The phenomenon of foliar absorption, or the associated agricultural practice, has been described as foliar feeding, nutrient absorption by above-ground plant parts, extraradical feeding, non-root feeding and "Blätterdungung." Compensation limited nitrogen fertilization for plants may be achieved through foliar nutrition with this element (Smolen and Sady, 2008). Nitrogen counts among elements with the most yield forming effect. However, too intensive fertilization with this element leads to the contamination of the natural environment due to NO_3 leaching out by precipitation waters into the soil profile and further, to ground waters and surface watercourses (Kellman and Hillaire-Marcel, 2003). Nitrogen losses also occur as a result of nitrogen volatilization into the atmosphere as nitrogen oxides (Laegreid et al., 1999). In order to reduce the burden to the natural environment caused by nitrogen fertilization, optimal crop cultivation methods are sought to efficiently diminish the negative effect of nitrogen compounds on the environment, and ensure high plant yields at the same time (Rahn, 2002).

Under variable soil and climatic conditions it is difficult to estimate the amount of nitrogen released in the process of soil organic matter mineralization. The results of research conducted by Guerette et al. (2002) revealed that the quantity of nitrogen released to soil from food remnants also depends on the species of cultivated plant.

The concentration of N-NO_3 in soil is also considerably influenced by the nitrification process. In order to stabilize N-NH_4 form in soil, fertilizers with nitrification inhibitors, for instance, 3, 4-dimethylpyrazol phosphate (DMPP) (Ha¨hndel and Wissemeier, 2004; Gioacchini et al., 2006) are used. Stabilization of N-NH_4 form in soil may result in improved utilization of fertilizer nitrogen by plants and a decrease in the level of nitrate accumulation in the har-vested portion. Generally, when crops are fertilized with reduced forms of nitrogen (N-NH_2, N-NH_4), yield with a lower level of NO_3 is obtained in case of plant nutrition with N-NO_3 form (Wanng and Li, 2004; Olfati et al., 2008). However, this relationship is not always reflected in prac-tice because of variable soil and climatic conditions and diverse ability of individual species and cultivars for ni-trate accumulation. Decreasing the quantity of nitrogen fertilizers applied and topdressing a larger proportion of the nitrogen decreases nitrate leaching from soil and improves nitrogen use efficiency of nitrogen utilization by plants. This solution is beneficial from the point of view of natural environment protection. However, nitrogen appli-cation for top dressing may lead to an elevated level of nitrate accumulation in the harvested portion (Smolen and Sady, 2008). On the other hand, diminishing the

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dose of nitrogen fertilization poses a hazard of lower plants yields. According to the reports of Rydz (2001) and Wojciechowska et al. (2005), the efficiency of foliar nutrition is dependent on soil, climate, fertilizer and the amount of nitrogen used. Nitrate is assimilated in the leaves and also in the roots. In most fully grown herbaceous plants, nitrate assimilation occurs primarily in the leaves, although nitrate assimilation in the roots often plays a major role at an early growth state of these plants (Heldt, 2005).

Fruit development in tomato is often accompanied by the depletion of foliar potassium to the detriment of both the plant and the fruit quality (Chapagain and Wiesman, 2004). Among the factors that influence the quality of tomato, potassium plays a key role, since it is involved in metabolic processes, such as the synthesis of proteins, enzyme activation, membrane transport processes, charge balance and the generation of turgor pressure (Dorais et al., 2001). As the tomato plant grows, the absorption of potassium increases to a relatively greater extent than that of other nutrients (Voogt and Sonneveld, 1997). When potassium uptake is lower than demand, foliar potassium is mobilized to the fruit, to the detriment of plant growth and fruit set and quality (Besford and Maw, 1975). Since the tomato fruit contains large concentrations of potassium, fruit development imposes considerable demands for this mineral, and depletion of foliar potassium is a common occurrence (Williams and Kafkafi, 1998) . The major problems associated with foliar application of fertilizers, particularly to annual plants (Swietlik and Faust, 1984) the cuticular barrier and leaf burn can be overcome by using low salt index fertilizers (that is, those free of Na and Cl) containing a low concentration of potassium and an appropriate adjuvant (Weinbaum, 1988).

The aim of the present study was to test the effects of foliar spraying of calcium nitrate and potassium phosphate from foliar fertilization on plant development, fruit yield and quality in green house tomatoes.

MATERIAL AND METHODS

In order to determine, the effect of different levels of nitrogen and potassium used in spraying solution on the yield and quality of tomato in a greenhouse culture, a two factor experiment was conducted with tomato cultivar `Rada` in an unheated plastic tunnel (100 m^2, 10 × 10 m) in 2008 in the Agricultural Faculty of Guilan University, Rasht, Iran (37^o 16' N). Each plot contains 6 plants. First factor was nitrogen with 3 levels (4, 6 and 8 $mmolL^{-1}$) prepared from calcium nitrate salt and other factor was potassium in 3 levels (2, 4 and 6 $mmolL^{-1}$) prepared from potassium phosphate salt in a com-pletely randomized experimental design (CRD) with three replications.

`Rada` cultivar seeds were sown in February 2007 in single plastic pots (12 × 11 cm) filled with white peat (TKS2®, Floragard, Germany). Transplantation took place on 23 February 2007 into greenhouse, at a plant density of 3.1 plants per m^2 for the remainder of the experiment after soil plowing and disking. The soil was a sandy loam, pH 6.6, containing total N (2.8%), total C (1.2%), a C/N ratio of 0.43, 10, 70, 110 $mg{\cdot}kg^{-1}$ of Ca, P, and K, respectively, and with an EC of 0.08 $ds{\cdot}cm^{-1}$.Plants were grown vertically, allowing the principal stem to grow. Pruning had taken in form of cutting the side shoots. Spraying solutions were prepared with tap water and sprayed three times during plant growth by 20 days between treatments with a sprayer. Temperature inside the greenhouse was controlled using automatic activation of the aerial heating fan with a TCL split type air condition-indoor unit system to maintain temperature between 27 and 18°C (day and night). No pesticide and insecticide were used during this trial.

Harvesting took place from 25 April to middle of Jun 2008 (8 times). During the trial three plants per experimental unit were sampled and fruit numbers and weight were determined. Fresh and dry weight were measured for the fruits and leaves after drying in a thermo-ventilated oven at 70°C.

The following characteristics were recorded, total yield, fruits number, mean fruit weight, main stem length and Stem diameter at first node, soluble solid content, total titrable acid, Vit. C, total nitrogen, phosphorous, potassium, calcium and magnesium in fruits and leaves. Soil pH was measured in 1:2.5 (v/v) soil–H_2O suspensions with a 716 DMS Titrino pH meter (Metrohm Ltd., Herisau, Switzerland) fitted with a glass electrode (Thomas, 1996). Total C was determined by oxidation with potassium dichromate and titration of excess dichromate with ammonium ferrosulfate (Kalembasa and Jenkinson, 1973). Electrolytic conductivity (EC) was determined in a saturated solution extract of the soil (Rhoades et al., 1989). The mineral N concentrations (NH_4-N and NO_3-N) in each fruit and soil samples were determined using Kjeldhal method.

Sub-samples (10 g) were pressed through cheese cloth to extract the juice. Total soluble solids were determined on a portable refractometer 300003 (Sper Scientific Ltd., Scottsdale, Ariz.) standardized with distilled water. Total titrable acid and Vit. C was measured by NaOH (0.1 M) titration and indophenol's method according to Horvitz et al. (1970) . Phosphorus, calcium and magnesium measured by spectrometry (Elliot and Dempsey, 1991) and potash was measured by flame photometry (Latiff et al., 1996) . The resultant data were subjected to analysis of variance using SAS statistical program and means were separated by Tukey test.

RESULTS

Yield and yield parameter

As shown in Tables 1 and 2, there is no significant effects observed between the different nutrient solutions on total yield and number of flowers per plant. The highest number of fruit per plant (28.33) and mean fruit weight (137.98 g) were obtained when 6 $mmolL^{-1}$ of each nutrient element was used (Table 11).

Fruit juice quality

Different nitrogen levels does not have significant effect on Fruits TSS, TA and Vit. C contents (Table 3). However potassium phosphate increased fruits TSS and TA when plants were sprayed with 4 $mmolL^{-1}$ potassium phosphate (Table 4). Highest amount of TSS (2.5 Brix) and TA (0.4%) were observed from combination of 6 and 4 $mmolL^{-1}$ nitrogen and potassium respectively. However the highest amount of Vit. C (16.30 mg. 100 g fresh matter^{-1}) was obtained from combination of 8 and 6 $mmolL^{-1}$ nitrogen and potassium respectively (Table 11).

Table 1. Effect of calcium nitrate on tomato yield and yield parameter.

Treatments (mmolL^{-1})	Yield (Mg. ha^{-1}) Ns	Number of fruits per plant **	Mean fruit weight (g) **	Number of flower branch per plant Ns
8	144.61^{az}	26.22^{a}	92.5^{b}	5.89^{a}
6	206.04^{a}	27.22^{a}	126.5^{a}	5.67^{a}
4	200.31^{a}	18.67^{b}	105.6^{b}	6.11^{a}

^{Z}Means in columns followed by different letters are significantly different
**, ns significant at P 0.01 and not significant.

Table 2. Effect of potassium phosphate on tomato yield and yield parameter.

Treatments (mmolL^{-1})	Yield (Mg. ha^{-1}) Ns	Number of fruits per plant*	Mean fruit weight (g)**	Number of flower branch per plant ns
6	190.32^{az}	25.22^{a}	125.91^{a}	16.06^{a}
4	143.67^{a}	23.00^{b}	103.34^{b}	16.69^{a}
2	216.96^{a}	23.89^{ab}	95.53^{b}	17.22^{a}

^{Z}Means in columns followed by different letters are significantly different. **,*, ns significant at P 0.01, P 0.05 and not significant.

Table 3. Effect of calcium nitrate on tomato fruit DM, TSS, TA and Vitamin C.

Treatments (mmol L^{-1})	TSS (°Brix) Ns	TA (%) ns	Vit. C (mg. 100 g fresh fruit^{-1}) Ns
8	1.54^{az}	0.31^{a}	12.78^{a}
6	1.63^{a}	0.33^{a}	12.57^{a}
4	1.74^{a}	0.35^{a}	13.72^{a}

^{Z}Means in columns followed by different letters are significantly different
ns: not significant.

Table 4. Effect of potassium phosphate on tomato fruit DM, TSS, TA and Vitamin C.

Treatments (mmolL^{-1})	TSS (°Brix) **	TA (%) **	Vit. C (mg. 100 g fresh fruit^{-1}) Ns
6	1.73^{az}	0.35^{a}	13.28^{a}
4	2.00^{a}	0.40^{a}	13.30^{a}
2	1.19^{b}	0.24^{b}	12.49^{a}

^{Z}Means in columns followed by different letters are significantly different
**, ns significant at P 0.01, and not significant.

Vegetative factors

Interaction between factors was significant for two vegetative measured characteristics including stem diameter at first node and stem height. The highest stem diameter (15.27 mm) and plant height (2.33 m) were obtained from combination of 8 mmolL^{-1} nitrogen $^{+}$ 6 mmolL^{-1} potassium and 4 mmolL^{-1} nitrogen $^{+}$ 6 mmolL^{-1} potassium respect-tively (Table 11).

Dry matter

Fruits and leaves dry matter decreased by increasing nitrogen solution (Table 5). Highest fruits and leaves dry matter (16.69%) were obtained from 4 mmolL^{-1} potassium (Table 6). However an interaction of two nutrient solu-tions do not showed any significant effect on fruits dry matter however the highest leaves dry matter (18.85%) were observed from 4 mmolL^{-1} nitrogen + 4 mmolL^{-1} pota-

Table 5. Effect of calcium nitrate on tomato stems diameter, stems height and Leaf DM

Treatments ($mmolL^{-1}$)	Stem Diameter (mm) Ns	Stem height (m) **	Fruit DM (%) **	Leaf DM (%) **
8	13.82^{az}	1.60^{b}	5.95^{b}	15.63^{b}
6	14.11^{a}	1.67^{b}	5.59^{b}	16.19^{b}
4	13.81^{a}	2.07^{a}	7.06^{a}	18.16^{a}

[Z]Means in columns followed by different letters are significantly different. **, ns significant at P 0.01, and not significant.

Table 6. Effect of potassium phosphate on tomato stems diameter, stems height and Leaf DM.

Treatments ($mmolL^{-1}$)	Stem Diameter (mm) *	Stem Height(m) Ns	Fruit DM (%) **	Leaf DM(%) Ns
6	14.36^{az}	1.82^{a}	6.37^{ab}	16.06^{a}
4	13.96^{ab}	1.72^{a}	6.64^{a}	16.69^{a}
2	13.43^{b}	1.79^{a}	5.58^{b}	17.22^{a}

[Z]Means in columns followed by different letters are significantly different. **,*ns significant at P 0.01, P 0.05 and not significant.

Table 7. Effect of calcium nitrate on tomato fruit elements.

Treatments ($mmolL^{-1}$)	P (mg. 100 g D^{-1}) **	Ca (mg. 100 g DM^{-1}) **	Mg (mg. 100 g DM^{-1}) **	KOH (mg. 100 g DM^{-1}) **	N (% in DM) **
8	32.59^{az}	6.30^{b}	5.28^{a}	5168.9^{a}	2.73^{a}
6	39.71^{a}	6.98^{b}	4.30^{b}	4186.6^{b}	2.26^{b}
4	13.18^{b}	15.24^{a}	4.88^{a}	4351.1^{ab}	2.36^{b}

[Z]Means in columns followed by different letters are significantly different. ** significant at P 0.01.

Table 8. Effect of potassium phosphate on tomato Fruit elements.

Treatments ($mmolL^{-1}$)	P (mg. 100 g DM^{-1}) Ns	Ca (mg. 100 g DM^{-1}) **	Mg (mg. 100 g DM^{-1}) ns	KOH (mg. 100 g DM^{-1}) ns	N (% in DM) ns
6	28.57^{az}	7.64^{b}	4.89^{a}	4208.9^{a}	2.48^{a}
4	31.01^{a}	10.85^{a}	4.88^{a}	4782.2^{a}	2.45^{a}
2	25.90^{a}	10.02^{a}	4.69^{a}	4715.6^{a}	2.41^{a}

[Z]Means in columns followed by different letters are significantly different. **, ns significant at P 0.01, and not significant.

ssium (Table 11).

Mineral elements

Highest amount of P (39.71), Ca (15.24), Mg (5.28), KOH (5168.9) and N (2.73) mg. 100 g dry matter^{-1} were obtained in tomato fruits from 6, 4, 8, 8 and 8 $mmolL^{-1}$ nitrogen respectively (Table 7). Potassium treatments does not have any significant effect on fruits P, Mg, KOH and N, however the highest amount of Ca (10.85 mg. 100 g dry matter^{-1}) was obtained from 4 $mmolL^{-1}$ potassium (Table 8). Tomato leaves contained highest amounts of Ca (19.67), KOH (6053.3) and N (3.91) mg.100 g dry matter^{-1} from 4, 6 and 8 $mmolL^{-1}$ nitrogen solution respectively (Table 9). 2 and 4 $mmolL^{-1}$ potassium solution caused the highest amount of Ca (19.70) and KOH (6115.6) mg 100 g dry matter^{-1} respectively (Table 10).

DISCUSSION

Application of nitrogen and potassium solution during growth period of tomato did not affect the total fruits yield

Table 9. Effect of calcium nitrate on tomato leaf elements.

Treatments (mmolL^{-1})	P (mg. 100 g DM^{-1}) Ns	Ca (mg. 100 g DM^{-1}) **	Mg (mg. 100 g DM^{-1}) ns	KOH (mg. 100 g DM^{-1}) **	N (% in DM) **
8	34.67^{az}	16.12^{b}	1.82^{a}	5813.3^{a}	2.78^{b}
6	34.08^{a}	17.79^{ab}	2.36^{a}	6053.3^{a}	3.91^{a}
4	32.62^{a}	19.67^{a}	2.22^{a}	4577.8^{b}	2.47^{b}

[Z]Means in columns followed by different letters are significantly different
**, ns significant at P 0.01, and not significant.

Table 10. Effect of potassium phosphate on tomato leaf elements.

Treatments (mmolL^{-1})	P (mg. 100 g DM^{-1}) Ns	Ca(mg. 100 g DM^{-1}) **	Mg(mg. 100 g DM^{-1}) ns	KOH(mg. 100 g DM^{-1}) **	N(% in DM) Ns
6	34.94^{az}	15.82^{b}	2.27^{a}	6093.3^{a}	2.92^{a}
4	34.96^{a}	18.06^{ab}	2.10^{a}	6115.6^{a}	3.07^{a}
2	31.47^{a}	19.70^{a}	2.02^{a}	4235.6^{b}	3.16^{a}

[Z]Means in columns followed by different letters are significantly different
**, ns significant at P 0.01, and not significant.

Table 11. Significant effect of nitrogen and potassium interaction in spraying solution on tomato plant parameters.

N (mmol. L^{-1})	K (mmol L^{-1})	Number of fruits per plant*	Mean fruit weight (g)*	TSS (°Brix)**	TA (%) **	Vit. C (mg. 100 g fresh fruit^{-1})**	Stem diameter (mm)**
4	2	18.33^{cz}	90.75^{bc}	1.10^{c}	0.22^{c}	13.80^{ab}	12.79^{b}
4	4	17.33^{c}	98.18^{bc}	2.40^{ab}	0.48^{a}	14.80^{ab}	14.45^{ab}
4	6	20.33^{bc}	128.02^{ab}	1.73^{abc}	0.35^{abc}	12.57^{ab}	14.20^{ab}
6	2	25.33^{a}	127.73^{ab}	1.17^{c}	0.23^{c}	13.10^{ab}	14.73^{ab}
6	4	28.00^{a}	113.80^{ab}	2.50^{a}	0.50^{a}	13.63^{ab}	14.00^{ab}
6	6	28.33^{a}	137.98^{a}	1.23^{c}	0.25^{bc}	10.97^{b}	13.61^{ab}
8	2	28.00^{a}	68.12^{c}	1.30^{bc}	0.26^{bc}	10.57^{b}	12.76^{b}
8	4	23.67^{ab}	98.05^{bc}	1.10^{c}	0.22^{c}	11.48^{b}	13.43^{ab}
8	6	27.00^{a}	111.73^{ab}	2.23^{abc}	0.45^{ab}	16.30^{a}	15.27^{a}

[Z]Means in columns followed by different letters are significantly different. **,* significant at P 0.01 and P 0.05.

and number of flowers. Similar results were obtained previously by Smolen and Sady (2008b) for carrot.

Fertilizer application method and also type of K fertilizer applied had a positive impact on ascorbic acid concentration in fruits (Table 4) due to the better availability of K to the plant. This is consistent with the research findings of Anac and Colcoglu (1995) who found that K increased the ascorbic acid concentration in tomato fruits. Similar trend was observed with respect to titrable acidity. Therefore, it can be said that availability of nutrients evenly with foliar fertigation was responsible for the improvement of ascorbic acid and titrable acidity.

Adamec (2002) demonstrated that foliar nutrition stimulates the intake of mineral nutrient by roots .On the other hand, Wittwer et al. (1967) demonstrated a higher absorption rate of N by the leaves treated with urea and those that is treated with nitrate or ammonium. Generally, the absorption rate of mineral nutrients by the leaves strongly depends on chemical properties of the cations. The higher the valence of a cation, the lower its ability to move into the cells (Mengel, 2002). However, among cations of the same valence, the penetration through a leaf surface decreases with the diameter of hydrated ion (Franke, 1967). In contrast to most mineral nutrients, leaf-absorbed N must be metabolized in the plant tissues before it is utilized. Plant N metabolism involves several reactions such as hydrolysis of urea, reduction of nitrate, and incorporation of ammonium/ammonia into amino acids. So far there has been no evidence indicating that metabolism of leaf- absorbed N is different than that of root-absorbed. Our results indicate that nitrogen fertilization in the form of calcium nitrate caused an increase

Table 11. Contd.

N (mmol L^{-1})	K(mmol L^{-1})	Stem height (m)**	Leaf DM (%) **	P (mg. 100 g fruit DM^{-1})**	P (mg. 100 g leave DM^{-1})**	Ca (mg. 100 g fruit DM^{-1})**
4	2	1.65[abcz]	17.86[ab]	4.47[d]	27.53[b]	16.97[a]
4	4	2.22[ab]	18.85[a]	13.93[cd]	35.84[ab]	18.14[a]
4	6	2.33[a]	17.75[ab]	21.13[bcd]	34.50[ab]	10.60[b]
6	2	1.77[abc]	17.02[abc]	31.87[abc]	30.60[ab]	7.41[bc]
6	4	1.63[bc]	14.52[bc]	44.83[a]	35.95[ab]	7.81[bc]
6	6	1.60[bc]	17.02[abc]	42.43[a]	35.70[ab]	5.73[c]
8	2	1.97[abc]	16.79[abc]	41.37[a]	36.29[a]	5.69[c]
8	4	1.30[c]	16.70[abc]	34.27[ab]	33.10[ab]	6.60[bc]
8	6	1.53[bc]	13.40[c]	22.13[bcd]	34.61[ab]	6.60[bc]

[z]Means in columns followed by different letters are significantly different. ** significant at P 0.01.

Table 11. Contd.

N (mmolL^{-1})	K (mmol. L^{-1})	Ca (mg. 100 g leaf DM^{-1})+**	Mg (mg. 100 g fruit DM^{-1})**	Mg (mg. 100 g leaf DM^{-1})**	KOH (mg. 100 g leaf DM^{-1})**	N(% in fruit DM)**	N (% in leaf DM)**
4	2	21.48[abz]	5.00[abc]	1.72[ab]	3413.33[e]	2.60[abc]	2.48[b]
4	4	24.84[a]	4.65[abc]	3.17[a]	6280.00[b]	2.23[c]	2.45[b]
4	6	12.68[c]	4.98[abc]	1.78[ab]	4040.00[cde]	2.25[c]	2.46[b]
6	2	21.60[ab]	3.87[c]	2.00[ab]	5560.00[bc]	2.39[bc]	4.15[a]
6	4	13.97[c]	4.80[abc]	1.75[ab]	6813.33[ab]	2.26[c]	4.20[a]
6	6	17.80[bc]	4.24[bc]	3.32[a]	5786.67[b]	2.13[c]	3.38[ab]
8	2	16.01[bc]	5.22[ab]	2.35[ab]	3733.33[de]	2.25[c]	2.85[b]
8	4	15.37[c]	5.18[ab]	1.38[b]	5253.33[bcd]	2.85[ab]	2.57[b]
8	6	16.98[bc]	5.44[a]	1.72[ab]	8453.33[a]	3.08[a]	2.92[b]

[z]Means in columns followed by different letters are significantly different. ** significant at P 0.01.

in the concentration of N-total in tomato fruits (Table 7). Fisher and Walker (1955) showed no effect of urea on the absorption of Mg and P by apple leaves. Kannan (1980) reported similar results indicating a lack of effect of urea on leaf absorption of some mineral nutrients. By other work of Smolen and Sady (2008a) with pot cultivation by carrot, nitrogen fertilization in the form of $Ca(NO_3)_2$, NH_4NO_3, $(NH_4)_2SO_4$ and $CO(NH_2)_2$ caused an increase in the concentration of N-total in storage roots in comparison with control plants which were unfertilized with nitrogen. Similar results were obtained in our research so that total N in fruits and leaves increased when sprayed with higher level of nitrogen.

Although in our research phosphorus and magnesium were uninfluenced when plants were sprayed with higher level of calcium nitrate, a decrease of calcium was observed by higher level of treatments in fruits and leaves dry matter because of saturation of uptake is tak-ing place at the most concentrated solution. Despite many studies on P absorption by different plant species, it is difficult to unambiguously state which of its chemical form the most is rapidly taken up by the leaves. According to Yogaratnam et al. (1981), P is the easiest absorbed as H_3PO_4. Therefore, it seems more experiments are needed to determine the function of calcium nitrate by foliage spraying of the calcium amount in tomato fruits and leaves. As shown in Table 2 the highest uptake of leaf-applied K from potassium phosphate solution was observed by tomato fruit weight and fruit numbers. Wittwer and Teubner (1959) showed the highest uptake of leaf-applied K from K-citrate solution. They speculated that citric acid radicals stimulated metabolism in leaf tissues which consequently led to increased K absorption. Driver et al. (1985) demonstrated that leaf absorption of K from K-sulphate was much lower than that of K-nitrate. Komosa (1990) found that penetration of K from the form K-chloride and K-nitrate through the isolated cuticular membrane was more rapid than that of K-sulphate.

Conclusion

Presently, foliar fertilization is frequently applied in agricultural practice. This fertilization mode should be recommended in an integrated plant production because it is environmental friendly and gives the possibility to achieve high productivity and good quality yields.

The results presented in this experiments revealed different effects of nitrogen and potassium as foliar nutrition and the interaction of these factors on the yield and quality of tomato. These differences can be as a result of soil and climatic conditions during the period of cultivation. The influence of fertilizer nitrogen and potassium on the discussed parameters can be significantly modified by the environmental conditions. Climatic conditions had a meaningful influence on the modification of the interaction between foliar nutrition. Results of experiment demonstrated that tomato crops fertilized with 6 $mmolL^{-1}$ nitrogen and 4 $mmolL^{-1}$ potassium contained greater quality. Despite many performed studies on foliar application of mineral nutrients, many aspects of the uptake and nutrient translocation within a plant are unfamiliar. Therefore, further research in this area is needed.

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