# THE EFFECT OF FERTILIZATION ON THE MINERALS CONTENTS IN TOMATOES

# EFECTUL FERTILIZĂRII ASUPRA CONȚINUTULUI DE MINERALE DIN TOMATE

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***Abstract:*** *In this paper was analyzed the macroelements (Na, K, Ca, Mg) and microelements (Fe, Mn, Cu, Zn, Ni, Pb) accumulated in tomatoes cultivated in field, in Romanian west area, after NPK fertilization. The experience was done in a cambric curiosum soil, with low acidity reaction and the high natural fertility potential favorable vegetables cultivation. The study was performed on control soil samples (without fertilizers) and soil samples after differentiated NPK fertilization in variable dozes: $N_{30}P_{30}K_{30}$, $N_{45}P_{45}K_{45}$, $N_{60}P_{60}K_{60}$, $N_{120}P_{60}K_{60}$. A field experiment was using tomatoes samples in different precocity steady: early (Export II) and middle tardy (Ace Royal). Na and K were determinate by atomic emission spectroscopy; Ca, Mg and microelements by atomic absorption spectroscopy. The highest values were observed for K, Mg, Ca, Na. The mineral fertilization doses and the precocity steady of tomatoes influence the content of minerals in tomatoes fruit.*

***Rezumat: I****n aceasta lucrare s-a urmarit determinarea continutul de macroelemente (Na, K, Ca, Mg) si microelemente (Fe, Mn, Cu, Zn, Ni, Pb) acumulate in fructele de tomate cultivate in conditii de camp, in zona de vest a tarii, in urma aplicarii îngrasamintelor minerale. Tipul de sol pe care s-a amplasat experienta este un cernoziom cambic, sol cu reactie usor acida, cu un bun potential de fertilitate favorabil culturii legumicole. Cercetarile s-au efectuat pe un sol nefertilizat, precum si in conditii de fertilizare diferentiala cu NPK in urmatoarele doze: $N_{30}P_{30}K_{30}$, $N_{45}P_{45}K_{45}$, $N_{60}P_{60}K_{60}$, $N_{120}P_{60}K_{60}$. Ca material de cercetare s-au folosit soiuri de tomate in diferite stadii de precocitate: timpuriu (Export II) si semitarziu (Ace Royal). Na si K au fost determinate prin spectroscopie de emisie atomica; Ca, Mg si microelementele prin spectroscopie de absorbtie atomica. K, Mg, Ca si Na reprezinta, in ordine crescatoare, cantitatea cea mai mare de macroelemente acumulate in tomate. Doza de fertilizare si stadiul de coacere al tomatelor influenteaza continutul de minerale din fruct.*

Fertilizing and liming practices influence the mineral composition of plant. Plants use nutrients in mineral form for their growth, regardless of whether the nutrients originate from organic or mineral sources. Of all plant nutrients, nitrogen is the one usually required in the highest quantities.(www.yara.com)

Nitrogen, phosphorus and potassium are considered fertilizer macronutrients because plants require them in a relatively large quantity for maximum growth and may need to be added to the soil annually. (Relf, D., 2002) The fertilizers are better used in optimum water supply condition. (Manescu, B.,2003)

**Macronutrients in vegetables:**

**Sodium (Na)** uptake from the soil is a major cause of salinity toxicity in plants, yet little is known about the mechanisms that underlie $Na^+$ influx.

**Potassium (K)** The concentration of K is vegetative tissue usually ranges from 1.0 to 4.0%. It plays an important role in the photosynthesis and food production processes within the plant, in the enzyme action of the plant, in increasing resistance to lodging and in the disease resistant mechanism of the plant. Potassium also plays an important part in the regulation of water conditions within the plant cell and loss of water from the plant by transpiration. Potassium is more closely connected with quality of the plant.

**Calcium (Ca)** Calcium is a constituent of the cell wall. It promotes early root development and growth and is necessary for the proper functioning of growing points, particularly root tips. It enhances uptake of $NO_3$-N and therefore is interrelated with metabolism. Calcium provides a base for neutralization of organic acids. Its concentration in plant ranges from 0.2 to 1.0%.

**Magnesium (Mg)** It is an important constituent of the chlorophyll molecule and is, therefore, essential for proper photosynthesis. It is associated with transfer reactions involving phosphate reactive groups, and is particularly important in the formation of seeds rich in oil. It helps in the translocation of starches and also regulates uptake of other nutrients. Magnesium activates many enzyme systems involved in carbohydrate metabolism and synthesis of nucleic acids. Its concentration in crops varies between 0.1 and 0.4%.

**Micronutrients in vegetables:**

**Zinc (Zn)** It is associated with iron and manganese in the formation of chlorophyll. It is involved in several enzyme systems and plays a role in nucleic acid and protein synthesis. Zinc is required in the synthesis of auxins from the amino acid tryptophan, the compound that regulate the plant's growth rate and development. It assists the utilization of phosphorus and nitrogen in plants. It also plays a regulatory role in the intake and efficient use of water by plants. Normal range in plants is 25 to 150 parts per million (ppm).

**Copper (Cu)** Copper is involved in chlorophyll formation and is a part of several important enzymes such as cytochrome oxidase ascorbic acid oxidase, lactase and phenolase. It participates in lignine formation, protein and carbohydrate metabolism and is possibly required for symbiotic N fixation. It promotes formation of vitamin A in plants. Normal concentration in plant tissue ranges from 5 to 25 ppm (parts per million).

**Iron (Fe)** Though not a constituent of chlorophyll, iron is essential for its formation. It is an essential component of many enzymes. Iron also enters into oxidation processes that releases energy from sugars and starches and reactions that convert nitrate to ammonium in the plant. It plays an essential role in nucleic acid metabolism. The sufficiency range of iron (Fe) in plant tissue is normally between 50 and 250 ppm. Iron deficiency is likely to occur when Fe contents are 50 ppm or less in the dry matter.

**Manganese (Mn)** It acts as a catalyst in several enzymatic and physiological reactions in plants and is a constituent of pyruvate carboxylase. It activates enzymes concerned with the metabolism of nitrogen and synthesis of chlorophyll. Manganese is also involved in the plant's respiratory processes. Normal concentration in plants typically ranges from 20 to 500 ppm. (http://engro.pakissan.com)

**Nickel (Ni)** Small nickel particles in the air settle to the ground or are taken out of the air in rain. Much of the nickel in the environment is found with soil and sediments because nickel attaches to particles that contain iron or manganese, which are often present in soil and sediments.

**Lead (Pb)** In general, plants do not absorb or accumulate lead. However, in soils testing high in lead, it is possible for some lead to be taken up. Higher concentrations are more likely to be found in leafy vegetables and on the surface of root. Since plants do not take up large quantities of soil lead, the lead levels in soil considered safe for plants will be much higher than soil lead levels where eating of soil is a concern. Generally, it has been considered safe to use garden produce grown in soils with total lead levels less than 300 ppm. The risk of lead poisoning through the food chain increases as the soil lead level rises above this concentration. Even at soil levels above 300 ppm, most of the risk is from lead contaminated soil or dust deposits on the plants rather than from uptake of lead by the plant. (Rosen, C., 2002)

Growing conditions are important for plants to absorb trace minerals. Potassium has a positive effect on keeping quality of tomato and additionally on taste of tomatoes. The uptake of K by fruit crops change rapidly and increase strongly during fruit development, together with a dramatic decrease in calcium uptake.Especially long term vegetable crop like tomato absorb such high quantities of minerals that it is impossible to supply these quantities as base dressind with fertilzers, because the osmotic pressure in the soil solution would increase to detrimental levels. (Voogt, W., 1981) For tomato a significant fraction of the absorbed K is partitioned to fruit. For K, the fractionis even higher than is for the total dry matter. However, the fraction of Ca in fruits is dramaticaly lower compared to K. The transition from vegetative to generative development will therefore cause a change in K/Ca ratio in the uptake. In addition, this effect is probably intensified by the fact that during the period of increased fruit load, the Ca uptake is reduced by the restricted root growth. (Noordwijk M.van, 1990) Ca is the dominant cation in the exchange complex of normal agricultural soils, its rate of movement into the plant is relatively slow in comparison with that of K. When this occurs, the absorbtion of Ca, Mg and Na is correspondind reduced. This may be to the disadvantage of the consuming animal and to man. (Bear,F.E., 1991)

Tomatoes contents 10 mg calcium, 237 mg potassium and 5 mg sodium per 100 g fresh matter (http://dieta.romedic) and after all authors the content ist 31.9 mg calcium, 396.7 mg potassium and 11.4 mg sodium per 100 g fresh matter. (http://www.freedomyou.com)

## MATERIAL AND METHOD

**Field experiments**: The experience was done in a cambic cernosium soil, with low acidity reaction and the high natural fertility potential favorable vegetables cultivation. Fertilization was control (without fertilizers) and mineral fertilizers (NPK) in variable doses: $N_{30}P_{30}K_{30}$, $N_{45}P_{45}K_{45}$, $N_{60}P_{60}K_{60}$, $N_{120}P_{60}K_{60}$. The fertilization doses and the application methods in tomatoes fertilization were to determine in correlations between agro chemistry factors. in different precocity steady: early (Export II) and middle tardy (Ace Royal).

Tomatoes samples were collected on June-July (varieties Export II) and August (Ace Royal). Tomatoes fruit were collected at thoroughly fruit maturity.

**Minerals determination**: 20 g fresh tomatoes were dried at $105^0$C to 3 hours, calcinated at $650^0$C for 3 hours; added 10 mL $HNO_3$ 0.5N solution and to run dry. The mineral residue were solubility in 25 mL $HNO_3$ 0.5N. (MAIA, 1983) For all macronutrients determination were using diluted samples of 1:100 in deionized water and for iron, manganese, cooper and zinc using diluted samples of 1:10. Nickel and lead were using work solution. Determination of Na and K were determinate by atomic emission spectroscopy and Ca and Mg by atomic absorption spectroscopy using Continuum Source Atomic Absorption Spectrometer contrAA®300 by Analytik Jena. Using standard work conditions - flame type: $C_2H_2$/air; flame height: 6mm; air flow: 568 L/h; acetylene flow: 80 L/h for Ca determination, 70 L/h for Mg, 60 L/h for Fe, 50 L/h for the other minerals. The wavelength dominate (λ) for each chemical elements: Na – λ= 588 nm, Na – λ= 588 nm, K – λ= 766 nm, Ca – λ= 422 nm, Mg – λ= 285 nm, Fe – λ= 248 nm, Mn – λ= 279 nm, Cu – λ= 324 nm, Zn – λ= 213 nm, Ni – λ= 232 nm, Pb – λ= 217 nm. The correlation coefficient for the calibration curves ($r^2$) its: Na - 0.9962, K – 0.9972, Ca – 0.9949, Mg – 0.9263, Cu – 0.9942, Zn – 0.9873, Mn – 0.9959, Fe – 0.9988, Pb – 0.9975, Ni – 0.9952.

## RESULTS AND DISCUSSIONS

In table 1 and 2 was presented macronutrients and micronutrients in tomatoes.

*Table1.*

**Macronutrients in tomatoes varieties**

| Tomatoes varieties | Fertilization doses | Na [ppm] | K [ppm] | Ca [ppm] | Mg [ppm] |
|---|---|---|---|---|---|
| Export II | Control | 68.80 | 1291.00 | 72.50 | 12.50 |
| | $N_{30}P_{30}K_{30}$ | 38.80 | 1247.00 | 123.75 | 80.00 |
| | $N_{45}P_{45}K_{45}$ | 46.20 | 1110.00 | 52.50 | 52.50 |
| | $N_{60}P_{60}K_{60}$ | 21.20 | 1102.00 | 237.50 | 87.50 |
| | $N_{120}P_{60}K_{60}$ | 18.75 | 945.00 | 72.50 | 72.50 |
| Ace Royal | Control | 62.50 | 975.00 | 57.50 | 12.50 |
| | $N_{30}P_{30}K_{30}$ | 13.70 | 922.50 | 86.25 | 62.50 |
| | $N_{45}P_{45}K_{45}$ | 27.50 | 836.20 | 172.50 | 31.25 |
| | $N_{60}P_{60}K_{60}$ | 20.00 | 720.00 | 235.50 | 91.25 |
| | $N_{120}P_{60}K_{60}$ | 37.50 | 590.00 | 95.00 | 16.25 |

The highest content of K is observed in control samples in two tomatoes sorts (1291.00 ppm for Export II and 975.00 ppm for Ace Royal) and decreased upon a time uptake fertilization doses.

Na content were higher in control samples for two tomatoes samples (68.80 ppm for Export II and 62.50 ppm Ace Royal). Lowest sodium content was observed in early precocity steady sorts (18.75 ppm) a $N_{120}P_{60}K_{60}$ and in middle tardy varieties

Ca and Mg content was lowest in two sorts in control samples (12.50 ppm Mg, 72.50 ppm Ca in Export II and 57.50 ppm Ca in Ace Royal). The highest calcium accumulation content is observed in Export II (237.50 ppm) and in Ace Royal (235.50 ppm) by $N_{60}P_{60}K_{60}$ fertilization doses. Magnessium highest values is observed in Export II (87,50 ppm) and in Ace Royal (91.25 ppm) a that fertilization doses.

*Table 2.*

**Micronutrients in tomatoes varieties**

| Tomatoes varieties | Fertilization doses | Fe [ppm] | Mn [ppm] | Cu [ppm] | Zn [ppm] | Ni [ppm] | Pb [ppm] |
|---|---|---|---|---|---|---|---|
| Export II | Control | 3.55 | 0.28 | 0.46 | 1.08 | 0.09 | 0 |
| | $N_{30}P_{30}K_{30}$ | 4.14 | 0.46 | 0.64 | 1.39 | 0.09 | 0 |
| | $N_{45}P_{45}K_{45}$ | 3.58 | 0.52 | 0.65 | 1.01 | 0.08 | 0 |
| | $N_{60}P_{60}K_{60}$ | 4.98 | 0.56 | 0.64 | 1.36 | 0.08 | 0 |
| | $N_{120}P_{60}K_{60}$ | 4.43 | 0.49 | 0.91 | 2.55 | 0.09 | 0 |
| Ace Royal | Control | 6.26 | 0.29 | 0.79 | 1.08 | 0.09 | 0 |
| | $N_{30}P_{30}K_{30}$ | 5.10 | 0.59 | 1.09 | 0.85 | 0.07 | 0 |
| | $N_{45}P_{45}K_{45}$ | 4.90 | 0.49 | 0.77 | 0.86 | 0.07 | 0 |
| | $N_{60}P_{60}K_{60}$ | 3.85 | 0.35 | 0.75 | 0.69 | 0.08 | 0 |
| | $N_{120}P_{60}K_{60}$ | 4.46 | 0.48 | 1.24 | 1.09 | 0.07 | 0 |

Fe has the highest content in Export II by $N_{60}P_{60}K_{60}$ fertilization doses (4.98 ppm) and for Ace Royal – 6.26 ppm in control samples. The lowest content in Fe was observed a control samples for Export II (3.55 ppm) and in $N_{60}P_{60}K_{60}$ fertilization doses for Ace Royal (3.85 ppm).

Mn accumulation is observed a $N_{60}P_{60}K_{60}$ (0.56 ppm) for Export II and a $N_{30}P_{30}K_{30}$ for Ace Royal (0.59 ppm). In control samples Mn values is very low (0.28 ppm for Export II and 0.29 ppm for Ace Royal).

The highest content in Cu and Zn was identified in two tomatoes sorts a $N_{120}P_{60}K_{60}$ fertilization doses. Because in high concentration these two metals are possible toxic, the contents in vegetable are limited. Maximum limits accept in Romanian legislation for heavy metals: Cu-5.0 mg/kg fresh matter, Zn – 1.0mg/kg, Pb -0.5 mg/kg. (Ordinance 975/1998).

Ni is present only in trace at 0.07-0.09 ppm; no observed differences between fertilization doses and tomatoes precocity steady.

Pb is not present in tomatoes fruit.

## CONCLUSIONS

The highest values were observed for K, Ca, Na, Mg. The high mineral content K, Ca, Na are benefic mineral was identified in control samples.

Precocity steady influence upside down Fe accumulation in tomatoes.

The mineral fertilization doses influence the mineral content in tomatoes fruit and precocity steady not.

This area is favorable to tomatoes products with highest macronutrients contents.

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