

INFLUENCE OF NPK FERTILIZATION ON NUTRITIONAL QUALITY OF TOMATOES

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Abstracts. The influence of the rate of fertilizer on tomatoes fruit quality aspects such as taste and content of nutritionally important compounds were investigated in this paper. The tomatoes were analyzed for sugar content, titrable acidity, vitamin C (ascorbic acid), lycopene, phenolic compounds and total antioxidant activity by FRAP.

The experience was done in a cambic cernosium 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 doses: N₃₀P₃₀K₃₀, N₄₅P₄₅K₄₅, N₆₀P₆₀K₆₀, N₁₂₀P₆₀K₆₀. The fertilization doses and the application methods in tomatoes fertilization were to determine in correlations between agro chemistry factors.

A field experiment was using tomatoes samples in different precocity steady: early (Export II) and middle tardy (Campbell 1327).

The NPK fertilization doses were affect the quality of tomatoes fruit.

INTRODUCTION

The tomato is the fruit of the plant *Lycopersicum esculentum* and is a member of the *Solanaceae* family. (<http://whfoods.org>).

The tomato is one of the most commonly grown fresh market vegetables. The consumers define quality. For tomatoes, the most important quality factors for consumers acceptance are that they look and taste good, are firm and have a good nutrient value. (Grierson, 1986).

Quality can be characterized by functional values that can be measured or analysed.

The chemical composition and content of nutrients that are important for the human diet and determine the nutritional quality of a product. (Hauffmann, 2002) Tomatoes are especially important for the human diet because of their content of vitamin C, carotenes, lycopene and phenolic compounds. (Davey, 2000).

Tomatoes are a great vegetable loaded with a variety of vital nutrition. Tomatoes are now available year-round, the truly wonderful qualities of tomatoes are the best when then they are in season from July through September. Tomatoes are an excellent source of vitamin C, vitamin A and vitamin K. They are also a very good source of molybdenum, potassium, manganese, dietary fiber, chromium and vitamin B1. In addition, tomatoes are a good source of vitamin B6, folate, cooper, niacin, vitamin B2, magnesium, iron, pantothenic acid, phosphorus, vitamin E and protein. Nutritional profile including carbohydrates, sugar, soluble

and insoluble fiber, sodium, vitamins, minerals, fatty acids, aminoacids and more. (<http://whfoods.org>)

Tomatoes need moderate to high levels of P and K. On deficient soils, most needs be supplementary P and K as indicated by soil test results. Potassium is a particularly important nutrient for tomatoes. (Diver, 2005)

Of the major nutrients, **nitrogen (N)** is often required in the greatest quantity by crops, primarily for vigor and yield. Nitrogen plays a key role in chlorophyll production and protein synthesis. When nitrogen is deficient, plants develop yellow or pale leaves and their growth is stunted. **Phosphorus (P)**, is a vital component of adenosine triphosphate (ATP) which supply the energy for many processes in the plant. Phosphorus rarely produces spectacular growth responses, but is fundamental to the successful development of all crops. **Potassium (K)** is needed by virtually all crops and often in higher rates than nitrogen. Potassium regulates the plant's water content and the expansion. It is key to achieving good yield and quality in cotton and critical for increasing the size, juice content and sweetness of fruit. (<http://yara>) Several studies have directly or indirectly examined the effect of plant nutrition on tomatoes. Of the mineral nutrients, K by influencing the free acid content and P due to its buffering capacity, directly affect tomato quality. Nutrition treatment was found to have a significant positive effect on tomato quality, color and acceptability. Potassium and phosphorus nutrition has a positive effect on fruit sugar and acid content. (Mikkelsen, 2005)

The taste of the tomato fruits depend on the variety, state of maturity at harvest, amount of nutrient during growth, environmental stress and water management. **Field grown tomatoes normally have more flavor than tomatoes growth in glasshouses.** (Hobson, 1988) High sugar and high acid contents generally have a favorable effect on taste. (Mikkelsen, 2005) Lycopene is the most abundant carotenoid present in red tomatoes, comprising up to 90% of the total carotenoids present. Lycopene is the pigment principally responsible for the characteristic deep-red color of ripe tomato fruits and tomato products. Increasing clinical evidence supports the role of lycopene as a micronutrient with important health benefits, because it appears to provide protection against a broad range of epithelial cancers. (Shi, J., 2000)

MATERIAL AND METHOD

Field experiments

Soil samples were taken (0-25 cm depth) before and after fertilization.

Fertilization was control (without fertilizers) and mineral fertilizers (NPK) in variable doses: $N_{30}P_{30}K_{30}$, $N_{45}P_{45}K_{45}$, $N_{60}P_{60}K_{60}$, $N_{120}P_{60}K_{60}$.

Analytical methods of soil samples

Soil properties were analyzed using the following methods: pH was determined in aqua solution.

Total N (%) was determined by the Kjeldahl method, digested in H_2SO_4 distilled and titrated with 0.1M NaOH. Phosphorus were determined by spectrophotometry using Spectrophotometer UV-VIS SPECORD 205 by Analytik Jena and Potassium by flame photometry method. (MAIA, 1983) Were used chemicals and reagents from Merck; deionized water.

Analytical methods of tomatoes samples

Tomatoes samples were collected on June-July (varieties Export II) and August (Campbell 1327).

Determination of sugar content (Brix value): Tomatoes samples were homogenized and centrifuged for 10 min. The supernatant was used to measure the sugar content using a refractometer method by hand refractometer Carl Zeiss Jena . The results were reported as °Brix at 20°C. All determination was repeated for three times.

Determination of lycopene: Lycopene in the tomato samples was extracted by hexane:ethanol:acetone (2:1:1) mixture following the method of Sharma and Le Maguer (1996). One gram of the homogenized samples and 25 mL of hexane:ethanol:acetone, which were then placed on the rotary mixer for 30 min., adding 10 mL distilled water and was continued agitation for another 2 min. The solution was then left to separate into distinct polar and non-polar layers. The absorbance was measured at 472 nm and 502 nm, using hexane as a blank. The lycopene concentration was calculated using its specific extinction coefficient ($E_{1\% 1\text{ cm}}$) of 3450 in hexane at 472 nm (Toor, R.K, 2006) and 3150 as 502 nm.(Gergen I., 2004) The lycopene concentration was expressed as mg/100g fresh matters.(Toor, R.K, 2006) All determination was repeated for three times. Absorption determination for lycopene content was using Spectrophotometer UV-VIS SPECORD 205 by Analytik Jena.

Determination of ascorbic acid (vitamin C): An ascorbic acid content was estimated titrimetrically by 2,6-Dichlorophenolindophenol Natrium. 5 mL of vegetable extracts was diluted with 10 mL water, ad 1 mL HCl 1N and was titrated with 1 mM solution 2,6-Dichlorophenolindophenol Natrium to pink color (Gergen I., 2004). The results were expressed as μM ascorbic acid/100 g fresh matter. All determination was repeated for three times.

Acidity determination: The titrable acidity was measured on fresh samples using titrimetrically method that measured the amount of 0.1 M NaOH required to neutralize the acids of tomatoes in phenolphthalein presence. The results were expressed as E/100 g fresh matter. (MAIA, 1983) All determination was repeated for three times.

Determination of phenolic compounds:

For determination phenolic compounds and total antioxidant capacity sample it was made the alcoholic extraction: 10 g of each sample were mixed with 10 mL ethanol solution (50%), and after 30 minutes were filtered. Ethanol extracts were diluted than 1/10 with ethanol solution (50%).

It was used the following reagents: 2.0 M Folin-Ciocalteu phenol reagent, gallic acid and anhydrous carbonate. The content of total polyphenolic compounds in tomatoes ethanol extracts diluted 1/10 was determined by Folin-Ciocalteu method (1927). For the preparation of calibration curve 0.5 mL aliquot of 0.2, 0.4, 0.8 and 1.2 $\mu\text{M/mL}$ aqueous gallic acid solution were mixed with 2.5 mL Folin-Ciocalteu reagent (diluted ten-fold) and 2.0 mL sodium carbonate (7.5%). The absorption was read after 2 h at 20°C, at 750 nm. All determinations were repeated for three times. Total content of polyphenols in tomatoes in gallic acid equivalents (GAE) was calculated. Correlation coefficient (r^2) for calibration curve was 0.9986. (Gergen I., 2004)

Determination of total antioxidant capacity (TAC) by FRAP method:

FRAP method depend upon the reduction of ferric tripyridyltriazine complex to the ferrous tripyridyltriazine by a reductant at low pH. This ferrous tripyridyltriazine complex has an intensive blue color and can be monitored at 593 nm. Reagents: acetate buffer, 300mM/L, pH 3.6; 10 mM/L TPTZ (2, 4, 6-tripyridyl-s-triazine) in 40 mM/L HCl; 20 mM/L $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ in distilled water. FRAP working solution: 25 mL acetate buffer, 2.5 mL TPTZ solution and 2.5 mL FeCl_3 solution. The working solution must be always freshly prepared. Aqueous solution of known Fe (II) concentration was used for calibration, in a range of 0.1-0.8 mM/L. For the preparation of calibration curve 0.5 mL aliquot of 0.1, 0.2, 0.4, 0.6, 0.8 $\mu\text{M/mL}$ aqueous Fe(II) as Mohr salts solution (1mM) were mixed with 2.5 mL FRAP working

solution; FRAP reagent was used as blank. The absorption was read after 10 min. at 25 °C and 593 nm. All determinations were repeated for three times. Total antioxidant capacity in tomatoes in Fe (II) equivalents was calculated. Correlation coefficient (r^2) for calibration curve was 0.9677.(Gergen I., 2004)

RESULTS AND DISCUSSIONS

In table 1 was presented soil agrochemical parameters before experiment.

Table 1

Soil agrochemical parameters before experiment			
pH	N(%)	P(ppm)	K (ppm)
6.34	0.29	163	160

The soil analysis show that soil its favorable for tomatoes cultivation.

The fertilization was applied in spring, with four weeks before tomatoes plantation.

In table 2 and 3 was present the values content of nutritionally important compounds were investigated in this paper.

Table 2

The nutritionally compounds content in Export II varieties tomatoes samples

Fertilization doses	Compounds content						
	Sugar [°Brix]	Licopen $\lambda=472$ nm [mg/100g]	Licopen $\lambda=502$ nm [mg/100g]	Vit.C [μM vit.C/100g]	Acidity [E/100g]	Phenolic compounds [μM/100g]	TAC (FRAP) [μMFe/100g]
Control	6.4	5.14	4.34	15.0	0.32	115.2	356
N ₃₀ P ₃₀ K ₃₀	5.1	6.12	5.15	22.0	0.32	130.6	426
N ₄₅ P ₄₅ K ₄₅	6.4	5.27	4.40	28.0	0.24	133.2	300
N ₆₀ P ₆₀ K ₆₀	5.8	7.40	6.41	25.0	0.24	136.0	336
N ₁₂₀ P ₆₀ K ₆₀	6.0	3.15	2.59	23.0	0.24	97.4	320

Table 3

The nutritionally compounds content in Campbell varieties tomatoes samples

Fertilization doses	Compounds content						
	Sugar [°Brix]	Licopen $\lambda=472$ nm [mg/100g]	Licopen $\lambda=502$ nm [mg/100g]	Vit.C [μM vit.C/100g]	Acidity [E/100g]	Phenolic compounds [μM/100g]	TAC (FRAP) [μMFe/100g]
Control	6.9	5.05	4.45	14.0	0.40	100.4	310
N ₃₀ P ₃₀ K ₃₀	6.5	2.28	1.84	15.0	0.32	75.6	290
N ₄₅ P ₄₅ K ₄₅	6.9	2.37	2.08	30.0	0.32	102.0	368
N ₆₀ P ₆₀ K ₆₀	5.2	2.09	1.74	26.0	0.24	136.0	476
N ₁₂₀ P ₆₀ K ₆₀	5.5	3.85	3.28	24.0	0.24	95.8	326

Sugar contents, for two tomatoes varieties, were higher in the fruit by control samples fertilization and in N₄₅P₄₅K₄₅ doses fertilization (6.4-6.9°Brix).

The lycopene content for Campbell varieties varied from 2.09-5.05 mg/100g at $\lambda=472$ nm and 1.74-4.45 mg/100g at $\lambda=502$ nm; highest content was accumulated in control samples (5.05 mg/100g at $\lambda=472$ nm and 4.45 mg/100g at $\lambda=502$ nm) and lowest in N₆₀P₆₀K₆₀ (2.09 mg/100g at $\lambda=472$ nm and 1.74 mg/100g at $\lambda=502$ nm). Highest lycopene content for Export II was found in N₆₀P₆₀K₆₀ (7.40 mg/100g at $\lambda=472$ nm and 6.41 mg/100g at $\lambda=502$ nm) and lowest in N₁₂₀P₆₀K₆₀ (3.15 mg/100g at $\lambda=472$ nm and 2.59 mg/100g at $\lambda=502$ nm).

Vitamin C content, for two varieties, ranged from 14.0-30.0 μM/100g fresh matter, highest content was found in N₄₅P₄₅K₄₅ rates fertilization and lowest in control samples.

The acidity content lowest upon a highest fertilization doses, in ranged from 0.32-0.24 E/100g fresh matter for Export II and 0.40-0.24 E/100 g fresh matter for Campbell sorts.

The antioxidant capacity was lowest in $N_{45}P_{45}K_{45}$ doses fertilization for Export II sorts (300 $\mu\text{MFe}/100\text{g}$ fresh matters) and in $N_{30}P_{30}K_{30}$ doses fertilization for Campbell sorts (290 $\mu\text{MFe}/100\text{g}$); highest content was accumulates in $N_{30}P_{30}K_{30}$ doses fertilization for Export II sorts (426 $\mu\text{MFe}/100\text{g}$) and in $N_{60}P_{60}K_{60}$ doses fertilization for Campbell sorts (476 $\mu\text{MFe}/100\text{g}$). Phenolic compounds was lowest in $N_{120}P_{60}K_{60}$ doses fertilization for Export II sorts (97.4 $\mu\text{M}/100\text{g}$) and in $N_{30}P_{30}K_{30}$ doses fertilization for Campbell sorts (75.6 $\mu\text{M}/100\text{g}$); highest content was accumulates in $N_{60}P_{60}K_{60}$ doses fertilization for two varieties (136 $\mu\text{M}/100\text{g}$).

CONCLUSIONS

High sugar content was found in control samples and depends on the variety.

The NPK fertilization doses and ripening steady influence lycopene accumulation in tomatoes fruit; the lycopene content was accumulated on high-quantity in early steady precocity and on small quantity in middle tardy sorts on the same fertilization doses ($N_{60}P_{60}K_{60}$).

Lycopene content is different from a variety of tomatoes to another.

The acidity content lowest upon a highest fertilization doses.

Using a different NPK rates fertilizations the influence on antioxidant capacity and phenolic compounds is different from a variety of tomatoes to another.

The NPK fertilization doses were affect the quality of tomatoes fruit.

This area is favorable to ecological vegetables production.

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