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# Effect of crop rotation and fertilization on quality of processing tomatoes

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## Abstract

Effect of crop rotation and fertilization on quality of tomato cv. New Yorker was studied in field conditions in a long term, static experiment, conducted in Skierniewice since 1922. Tomatoes in crop rotation were cultivated on same field every third year, whereas these in monoculture were continuously cultivated on same field for 9 consecutive years (1980-1988). The fertilization treatments included: 1) farmyard manure in rate of 40 t per hectare, annually, 2) mineral fertilization of 150 kg N, 100 kg $P_2O_5$ and 200 kg $K_2O$ per hectare, 3) farmyard manure plus mineral fertilization as in treatments 1 and 2 and, 4) mineral fertilization as in treatment 2 plus microelements in form of a multimineral, commercial fertilizer (Polichelat LS 7). Crop rotation had no significant influence on the content of soluble solids, colour and weight of fruits. However, tomato fruits from plants cultivated in rotation, as compared to those from monoculture, contained more organic acids and pectins, less nitrates, had lower pH and greater firmness. The effect of fertilization was similar in rotated and non-rotated cultivation. At combined manure and mineral NPK fertilization, tomato fruits showed higher content of soluble solids, organic acids and pectins than these from the other fertilization treatments. Fruits of plants fertilized with farmyard manure only had higher content of vitamin C and lower one of nitrates, soluble solids and organic acids and also lower firmness as compared these from other fertilization in trial.

## INTRODUCTION

Quality of the processed tomato products depends very much on the quality of tomato fruits. Results of experiments show that quality and in like manner yield of tomato fruits are influenced by cultural practices applied at growing of tomatoes (Chroboczek, 1962; Michalik et al., 1975; Fajkowska, 1976; Rumpel, 1986; Elkner, 1993). Literature data on effect of mineral fertilization on quality of tomato fruits are inconsistent. Some authors report that moderate NPK fertilization

increases the dry matter, sugars, vitamin C and pectins content in fruits, what leads to improved quality of the processed tomato products (A b d i l l a e v, 1969; S a p o ż n i k o v a et al., 1970), whereas according to others, such effect is practically not existing (T y l e r and M a y, 1984).

Scarce data exist on the effect of exclusively organic fertilization on quality of tomato fruits because research on fertilization effects is focused mainly on combined organic and mineral fertilization. Most of the authors agree that balanced organic and mineral fertilization secures high yield of tomatoes with desired processing quality (C h r o b o c z e k, 1962; S k ą p s k i et al., 1968; A g a e v et al., 1987).

The aim of this study was to investigate the effect of crop rotation and various fertilization of tomatoes on quality of tomato fruits.

## MATERIAL AND METHODS

In field experiments conducted in the period of 1980-1988, determinate tomato cv. New Yorker was grown from transplants planted in field between the 15th and 20th of May. The field was part of a long term, static rotation and fertilization experiment with vegetable crops, established in Skierniewice in 1922. Tomatoes in crop rotation were grown on the same field every third year (1981, 1984 and 1987) and were followed by onions and carrots, whereas these in monoculture were grown on same field for nine consecutive years. The soil of the experiment site is a sandy-loam podsol, formed on clay, interspersed with sand pockets, originating from a glacial moraine. The average annual precipitation rate for the experiment site is 531 mm and the average annual temperature is 7.9°C. The warmest month is July (average 18.4°C) and the coldest one is January (average -3.0°C).

Presented results derive from tomatoes grown on following fertilization treatments: 1. Farmyard manure (FYM) in rate of 40 t per hectare, annually, 2. Mineral NPK fertilization in rates of 150 kg N, 100 kg $P_2O_5$ and 200 kg $K_2O$ per hectare, 3. FYM + NPK fertilization as in treatments 1 and 2, and 4. NPK as in treatment 2 plus microelements. The microelements were applied in form of a commercial fertilizer (Polichelat LS 7) in amounts equivalent to 0.4 kg copper (Cu), 0.4 kg manganese (Mn), 0.6 kg Zinc (Zn),1 kg iron (Fe), 0.2 kg boron (B), 0.03 kg molybdenum (Mo) and 0.9 kg magnesium (Mg) per hectare. The FYM and NPK fertilizers were applied annually in autumn or spring respectively, whereas the microelements fertilizer was applied every third year to the forecrop of tomatoes. Plots were of 51 $m^2$ each and every treatment was replicated 4 times. Tomato plants were spaced 75 x 55 cm (26 666 plants/ha). Routine plant management was applied. Harvest was made in 5-7 day intervals and yield was graded according to official standards. Class A red tomato fruits from 3 consecutive harvests made in the middle of the harvest season of 1987 were collected for chemical analysis. Following components and features were analyzed: soluble solids (refractometrically), acidity (pH, on pH meter

with glass electrode), organic acids (expressed as citric acid after titration), pectins (colorimetric method), vitamin C (Tillmans method), nitrates (potentiometric method, using Orion nitrate electrode), color (with Hunter apparatus) and fruit firmness (with Instron apparatus). Processed tomato puree was analyzed for color and viscosity (with Brookfield viscosimeter) and for taste and flavour in sensory (organoleptica) evaluation with Tilgner method. Results were subjected to statistical analysis of variance with a two factorial split-plot method. Averages were compared using the t-Student test at $\alpha = 0.05$.

## RESULTS

Quality assessment of tomato fruits shows no greater effect of crop rotation on the content of soluble solids, vitamin C, weight and color of fruits. Rotation however influenced the content of organic acids, pectins, nitrates and also pH and firmness of fruits (Table 1 and 2). Fruits from plants grown without rotation had more nitrates, lower pH, less organic acids and pectins. Their firmness was also lower as compared to that from crop rotation. Fruit quality was also influenced by fertilization. Highest content of, soluble solids and nitrates was found in tomato fruits from plants fertilized with farmyard manure plus mineral NPK (Table 2).

Table 1

Effect of crop rotation and fertilization on some physical features of tomato fruits

| Features | Treatment | Color (a/b ) | Fruit weight (g) | Fruit firmness (N) |
|---|---|---|---|---|
| Cultivation | monoculture | 2.1 | 74.2 | 12.3 |
| | crop rotation | 2.2 | 76 | 14.7 |
| | $LSD_{\alpha = 0.05}$ | n.s | n.s | 1.4 |
| Fertilization | manure | 2.1 | 72.7 | 12.7 |
| | mineral NPK | 2.1 | 75.1 | 13.2 |
| | manure +mineral NPK | 2.2 | 75.0 | 14.2 |
| | mineral NPK + microelements | 2.2 | 73.9 | 13.8 |
| | $LSD_{\alpha = 0.05}$ | n.s | n.s | 0.8 |

Table 2

Effect of crop rotation and fertilization on some chemical features of tomato fruits

| Features | Treatment | Soluble solids (%) | Active acidity (pH) | Vitamin C (mg% d.m.) | Pectins (% d.m.) | Nitrates ($NO_3^-$-N) (mg/kg d.m.) |
|---|---|---|---|---|---|---|
| Cultivation | monoculture | 5.8 | 4.81 | 177.1 | 6.61 | 292 |
| | crop rotation | 6.1 | 4.51 | 204.3 | 7.44 | 229 |
| | $LSD_{\alpha = 0.05}$ | n.s | 0.10 | n.s | 0.30 | 16 |
| Fertilization | manure | 5.5 | 4.62 | 237.5 | 6.80 | 214 |
| | mineral NPK | 5.8 | 4.72 | 169.0 | 6.73 | 273 |
| | manure +mineral NPK | 6.6 | 4.55 | 179.3 | 7.63 | 298 |
| | mineral NPK + microelements | 6.0 | 4.75 | 170.2 | 7.01 | 257 |
| | $LSD_{\alpha = 0.05}$ | 0.7 | n.s. | 29.0 | 0.29 | 12 |

The content of vitamin C however was highest in fruits from plants fertilized with farmyard manure only. Fruit firmness from only manure fertilized plots was lower than from those where mineral fertilization was applied. No distinct effect of fertilization on color and weight of fruits was found. Fruits from plants fertilized with manure or with NPK fertilizers had, independently from rotation, significantly less pectins than those from the manure plus NPK fertilization, whereas the difference between rotated and non-rotated tomato culture were considerably smaller than in the other fertilization treatments (Fig. 1). Monoculture as compared to crop rotation increased the content of nitrates at all fertilization treatments. Lowest $NO_3^-$-N in tomato fruits was observed with farmyard manure fertilization only. The presence of NPK fertilization increased the $NO_3^-$-N content of tomato fruits in both the rotated and the non-rotated tomato culture (Fig. 2). The content of organic acids of tomato fruits was related to crop rotation and manure fertilization and was highest from plants in crop rotation, fertilized with manure plus NPK and slightly lower when manure only was applied. Fruits from plants with only mineral fertilization (NPK, as in treatment 2 or NPK + microelements, as in treatment 4) had relatively low organic acid content, irrespective from crop rotation (Fig. 3). Fruits from plants grown in rotation on manure plus NPK fertilized plots, had highest firmness. High firmness showed also fruits from non-rotated plants fertilized with manure plus NPK or with NPK plus microelements (Fig. 4). Tomato puree processed from fruits of

crop rotated plants showed higher viscosity and received higher sensory evaluation as compared that from fruits of plants grown in monoculture (Table 3).

It is proper to add that the tomato culture in experiment was in satisfactory good condition. The total yield of fruits in 1987 from plants grown in crop rotation and in monoculture was 84.0 and 76.3 tons per hectare respectively, wherease that from the manure, NPK, manure + NPK and NPK + microelements treatments was 62.1, 86.8, 89.3 and 82.4 tons per hectare respectively.

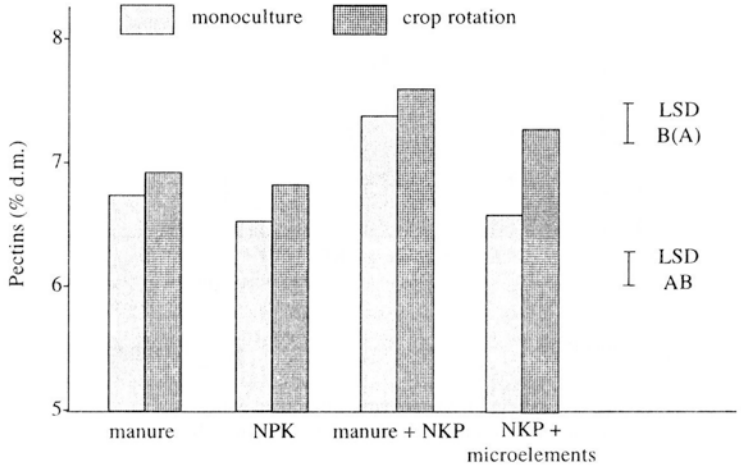


Fig. 1. Content of pectins in tomato fruits
Interaction of crop rotation (A) and fertilization (B)

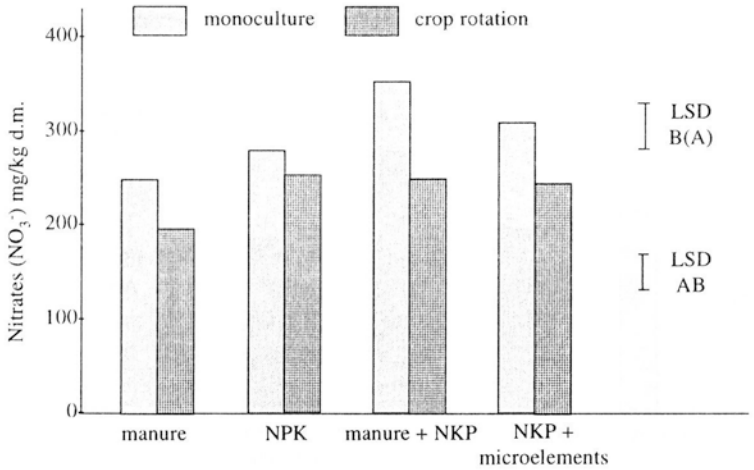


Fig. 2. Content of nitrates in tomato fruits
Interaction of crop rotation (A) and fertilization (B)

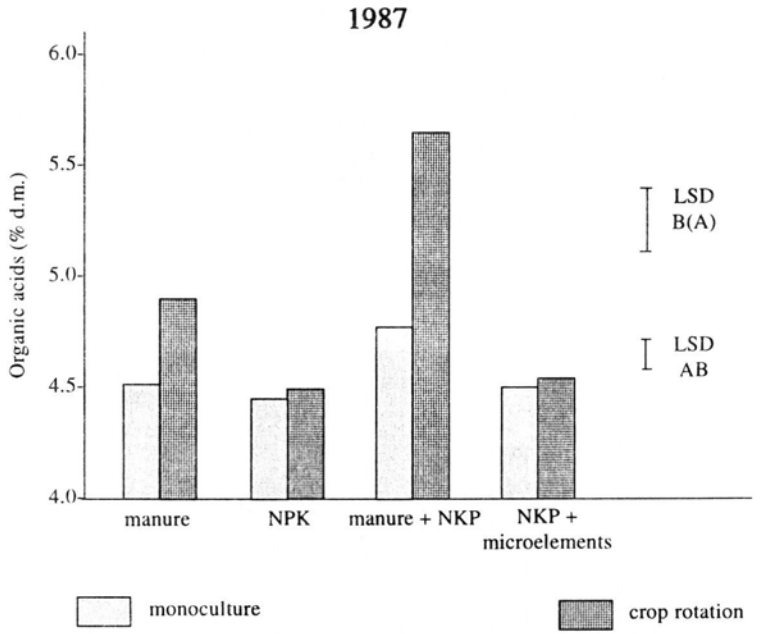


Fig. 3. Content of organic acids in tomato fruits
Interaction of crop rotation (A) and fertilization (B)

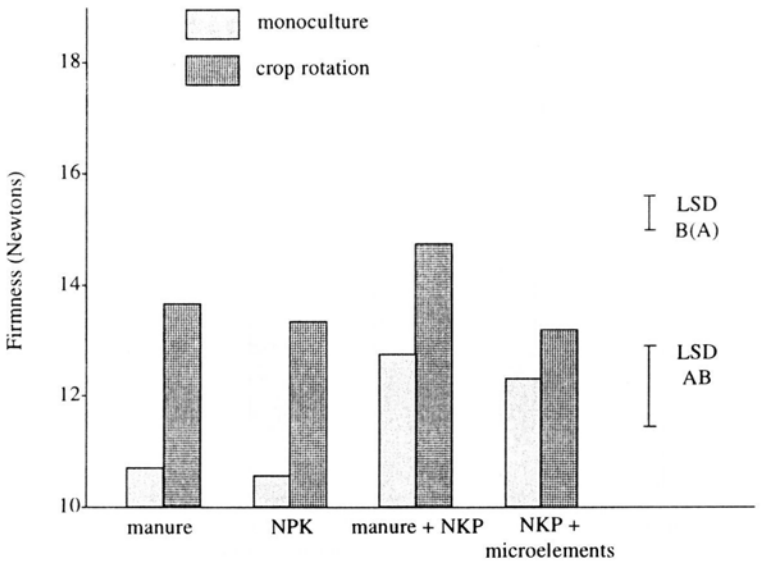


Fig. 4. Firmness of tomato fruits
Interaction of crop rotation (A) and fertilization (B)

Table 3

Effect of crop rotation and fertilization on the quality of tomato puree

| Features | Treatment | Color (a/b ) | Viscosity (m.Pa.s.) | Sensory evaluation (scores) |
|---|---|---|---|---|
| Cultivation | monoculture | 2.0 | 720 | 3.81 |
| | crop rotation | 2.1 | 1030 | 4.21 |
| | $LSD_{\alpha = 0.05}$ | n.s | 70 | 0.17 |
| Fertilization | manure | 2.0 | 850 | 4.28 |
| | mineral NPK | 2.0 | 835 | 3.96 |
| | manure +mineral NPK | 2.2 | 960 | 4.36 |
| | mineral NPK + microelements | 2.1 | 850 | 3.85 |
| | $LSD_{\alpha = 0.05}$ | n.s | 90 | 0.22 |

## DISCUSSION

Results of quality assessments of tomatoes grown on an unique long term static experiment with crop rotation and fertilization show that both, crop rotation and fertilization affect quality of tomato fruits. Fruits from plants grown in crop rotation were of better processing quality as compared those from plants grown in an eight years lasting monoculture. This was evident by the observed favourable features, such as fruit firmness, high content of organic acids and pectins and low content of nitrates in tomato fruits. Also the processed tomato puree showed positive effect of crop rotation by higher viscosity and higher sensory avaluation. Among the investigated fertilization treatments the combined application of farmyard manure and NPK fertilizers appeared to influence distinctly and desirably fruit firmness, soluble solids and pectins content of tomato fruits. FYM + NPK fertilization increased also the content of nitrates in tomato fruits, but in spite of that, the $NO_3^-$-N level of 298 mg/kg dry matter can be considered as very low and thus ignored. At only farmyard manure fertilization, the tomato fruits had highest content of vitamin C and lowest one of nitrates, out of all fertilization treatments in trial. This may be result of low nitrogen supply and would confirm the observed in early growth stages nitrogen deficiency symptoms on tomato and other plants species grown with FYM fertilization only.

Similar pattern in vitamin C and nitrates content in absence of mineral NPK fertilization was found in white winter cabbage (R u m p e l et al., 1995). Mineral NPK fertilization as compared to only farmyard manure one had no greater effect on organic acids and pectins contents, and also color and firmness of tomato fruits. It may be worth noticing that the added microelements to the NPK fertilizers had very little influence on the assessed quality features. This seems to support other investigations showing that in conditions of the long term, static experiment in Skierniewice, microelements are in satisfactory level for the needs of vegetable plants (R u m p e l et al., 1993).

## CONCLUSIONS

The conducted experiments with crop rotation and fertilization of tomatoes grown in a long term static fertilization and crop rotation experiment allow to form following conclusions:

1. Crop rotation as compared to monoculture improves quality of tomato fruits, what is evideht by increased firmness, higher content of organic acids and pectins of fresh tomato fruits and also by better viscosity, taste and flavour of the processed tomato puree;

2. Combined fertilization with farmyard manure and mineral NPK results in higher content of soluble solids, organic acids and pectins in tomato fruits as compared fertilization with only farmyard manure or mineral NPK fertilizers;

3. At sole manure fertilization, tomato fruits contain more vitamin C and less nitrates as compared with combined manure and NPK or only NPK fertilization.

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## Wpływ zmianowania i nawożenia na jakość pomidorów przeznaczonych dla przetwórstwa

### Streszczenie

Wpływ zmianowania i nawożenia badano na pomidorze odm. New Yorker uprawianym w wieloletnim, statycznym doświadczeniu płodozmianowo-nawozowym. Rośliny w zmianowaniu uprawiano na tym samym polu co 3 lata podczas gdy rośliny bez zmianowania (w monokulturze) uprawiano przez 9 kolejnych lat na tym samym polu po sobie. W obydwu sposobach uprawy stosowano jednolite nawożenie obejmujące następujące obiekty: 1. Obornik w dawce 40 t/ha corocznie, 2. Nawożenie mineralne w dawce 150 kg N, 100 kg $P_2O_5$ i 200 kg $K_2O$/ha, 3. Obornik plus nawożenie mineralne jak w obiektach 1 i 2, i 4. Nawożenie mineralne jak w obiekcie 2 + mikroelementy w postaci wieloskładnikowego nawozu „Polichelat LS 7". Zmianowanie nie wywierało istotnego wpływu na ekstrakt, barwę i wielkość owoców. Korzystny wpływ zmianowania wyrażał się natomiast w zwiększonej zawartości kwasów organicznych i pektyn, niższej zawartości azotanów i wyższej twardości owoców. Wpływ nawożenia był podobny zarówno przy zmianowaniu jak i w monokulturze. Połączone nawożenie obornikiem i NPK zapewniało wyższe zawartości ekstraktu, kwasów organicznych i pektyn w owocach pomidora aniżeli w pozostałych obiektach nawozowych. Owoce pomidora pochodzące z roślin nawożonych wyłącznie obornikiem miały wyższą zawartość witaminy C oraz niższą zawartość ekstraktu, kwasów organicznych i azotanów oraz niższą twardość od owoców pozostałych obiektów nawozowych.