EFFECTS OF SOIL TYPES AND NITROGEN FERTILIZER DOSES ON SOME CHEMICAL CHARACTERISTICS OF TOMATO, SWEET CORN AND PEPPER

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ABSTRACT
Our research project was aimed at the description of the nitrogen and carbon flows in soils and vegetable cultures. As a part of this project we made our experiments in the nursery garden of our Institute (Kecskemét College, Faculty of Horticulture), using irrigated and fertilized lysimeters. Three different soil types (sandy, alluvial and chernozem soils) were studied. At constant phosphorus and potassium fertilizer doses (P_{60}:K_{120}), four different nitrogen doses (0, 60, 120 and 180 kg.ha-1 N) were used. Total N levels and other parameters were determined in two harvesting times in tomato (type K-549) and sweet corn (variety 'Spirit') as well. According to other parameters of the tested vegetables, organic acid contents increased in tomato berry on sandy and alluvial soils at higher nitrogen fertilizer doses. Sugar content was higher in tomato grown on alluvial and chernozem soils. Nitrogen doses decreased sugar contents in chernozem in the case of both vegetables. The increase in vitamin C levels of tomato in sandy soil was slight due to higher nitrogen doses. The highest sugar content in sweet corn was measured due to farmyard manure treatment. According to green and red pepper test plants, the effect of nitrogen fertilizer (ammonium-nitrate) and barnyard manure on crop mass seemed to be highly positive in our experiments.

Keywords: nitrogen fertilizer, soil types, lysimeter, tomato, sweet corn

INTRODUCTION

The central object of our research project was to examine sustainable cropping through supplying nutrients in accordance with nutritive uptake and irrigation, and studying organic material uptake dynamics. For the examination of vegetable cultures a model imitating organic/inorganic carbon and nitrogen flow was used, and during our experiments microbiologic activity and organic material metabolism of soils were studied continuously in different textures and organic contents. We showed that high nitrogen addition treatments (120 and 180 kg.ha^{-1} N) accelerated cellulose decay in clay loam soil (SZILI-KOVÁCS ET AL., 2009). Intensive vegetable growing may encumber mainly the soil and natural and ground water among the environmental factors as a result of intensive irrigation and inadequate organic and inorganic nutrient use (NÉMETH, 2006; KÁDÁR, 2007).

In our recent study we focus on the influence of different nitrogen doses on crop mass and the chemical composition of some plant organs of tomato and sweet corn, as indicator plants.

MATERIAL AND METHOD

Our experiment series were carried out in the nursery garden of Faculty of Horticulture, Kecskemet College, as a part of the study project supported by the Hungarian Scientific Research Fund. The experiments were carried out in lysimeters with 0.6 m height and diameter, a drip irrigation system was used to ensure sufficient soil water supply to the tomato test plant, type K-549. The two variable treatments were as follow: three soil types (sandy, alluvial and chernozem) and four nitrogen fertilizer doses: 1. Control, 2. N_{60}:P_{60}:K_{120}, 3. N_{120}:P_{60}:K_{120}, and 4. N_{180}:P_{60}:K_{120} kg ha^{-1} N, P_2O_5 and K_2O active agent, in six repetitions. The most characteristic physical and chemical parameters of the examined soil types were described in our other paper (VÉGH ET AL., 2007). Basic fertilizer was applied before planting as a slow release fertilizer Cropcare (10:10:20) in 600 kg ha^{-1}. Nitrogen was applied three and six weeks later as 34% NH_4NO_3. In the case of sweet corn, the applied N doses were the same, with the exception in the treatment 3: N_{120}:P_{60}:K_{120} was completed with barnyard manure in 150 t ha^{-1} dose incorporated to soil before sowing. In the case of green and red pepper test plants N-treatments were the follows: 1. Control, 2. N_{60}:P_{60}:K_{120}, 3. N_{120}:P_{60}:$K_{120+165}$ t/ha barnyard manure, és 4. N_{180}:P_{60}:K_{120} kg/ha N, P_2O_5 és K_2O, in six replicates.

Laboratory tests were made in the Soil and Plant Testing Laboratory of our Faculty of Horticulture (Kecskemét College). Total nitrogen, phosphorus, potassium contents in tomato leaves and fruits, acid, sugar and vitamin C levels in tomato fruit were analyzed in two harvest times (1st examination: 15th August and 2nd examination: 28th August). We determined total nitrogen levels in young (apical) and old (basal) leaves as well. Next year sweet corn, variety 'Spirit' (SG), a short vegetation period species, was used in our experiments. Leaf samples of sweet corn were collected three times: first in 5-6 leaves stage, second at the beginning of silking and third at harvest. Total nitrogen levels were determined by Kjeldahl method (FOSS Kjeltec 2300), total phosphorus and potassium contents were analyzed by ICP-OES spectrometer (HORIBA Jobin Yvon) after microwave digestion. Further parameters including total free acid content, total sugar (Schoorl method), and vitamin C were determined by volumetric analysis. Red pepper powder quality was characterized by ASTA (American Spice Trade Association) level.

RESULTS

At the first harvest time, the lowest total nitrogen content was shown in tomato plant leaves grown in sandy soil (1.69%), while this was higher in chernozem and alluvial soil, by 18 and 50%, respectively. At the end of peduncle (younger, apical leaves) the total N content was 3.65% and at the basal part of peduncle (basal, older leaves) this value was 2.42%.

The results of the second harvest time analysis showed total N levels of 2.41% in young leaves and 2.03% in old leaves grown in sandy soil, on the average. Increasing nitrogen doses increased N content both in young and old leaves in sandy soil, which must have been the result of the poor nitrogen supply of this soil type.

According to the tomato fruit analysis, increasing N doses increased total N content by 6-32% in both harvest times as compared to control. On the contrary, total phosphorus levels decreased continuously by increasing N fertilizer doses in sandy soil (from 0.74 to 0.34% in young leaves and from 0.70 to 0.41% in the old ones). This effect in the fruit was negligible.

According to our crop mass investigation, there was a slight increase in the total crop mass of tomato berry from sandy soil to alluvial and chernozem soils (*Figure 1*). This may be the result of the naturally existing difference in the nutrient supplier capacity of these soils. N_{120} and N_{180} N doses increased crop mass statistically significantly as compared to the control, in all soil types (LSD 5%), independently of the soil types.

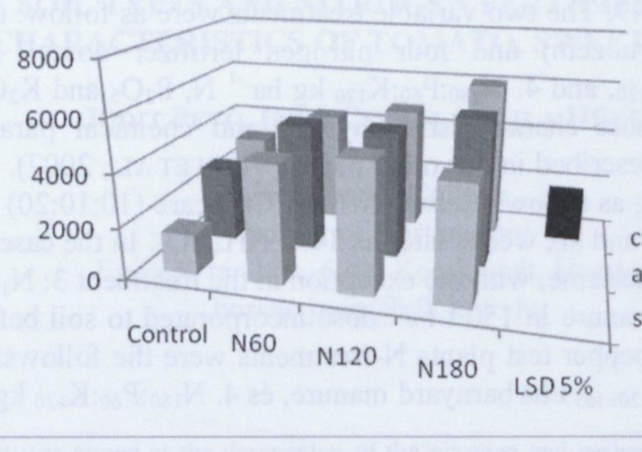

Figure 1. Changes in total crop mass of tomato (g/lysimeter) after different N fertilizer doses

Our results, concerning the mass of tomato berries, show the highest average crop mass of berry in control parcels, coupled with the lowest total crop mass. Significantly negative correlation between total crop mass and average mass of berries was also shown. It is in accordance with the known observations: rich crop couples with smaller crop size.

According to acid content of tomato fruit it was 0.38% in sandy soil, 0.43% in alluvial and 0.53% in chernozem soil, on the average. At to the 1st harvest time higher N doses increased the acid level in sandy and alluvial soils, while the highest N_{180} kg ha^{-1} dose did not result in increasing acid levels in chernozem because of the balanced nutritive supply in this type. At the second examination time a tendency to increase in acid content was shown in sandy soil, but it equalized in alluvial and chernozem soils, due to increasing N fertilizer doses.

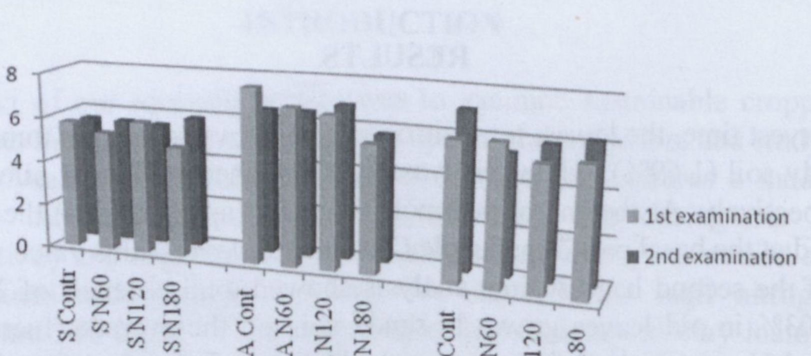

Figure 2. Changes in sugar/acid ratio of tomato fruit grown in sandy (S), alluvial (A) and chernozem (C) soil after different N fertilizer doses

Mean sugar content in tomato berry increased to 2.84 in alluvial and to 3.14 in chernozem soil as compared to 2.09% level measured in fruit grown in sandy soil (1st examination). Sugar contents were almost the same at the second examination, irrespectively of soil types. The sugar level enhancing effect of higher N fertilizer doses was shown only in sandy soil.

Vitamin C content in tomato fruit increased slightly after nitrogen treatment in sandy soil. In alluvial soil this increase was less while a remarkable decline was shown in chernozem at 60 and 120 kg ha^{-1} nitrogen doses. Vitamin C content decreased in all examined soil types at the 2nd examination time.

Changes in sugar/acid ratio in tomato berry are shown in *Figure 2*. The illustrated changes are in agreement with the above mentioned changes in acid and sugar levels of tomato berry during the growing season. The highest sugar/acid ratios were reached on alluvial soil at the first examination, which differed significantly from the other two soil types (SD 5%). Increase in N fertilizer doses did not cause significant changes.

According to sweet corn test plant analysis total N content in leaves were the highest at the beginning of the vegetation period, reaching about 1% till harvesting. At harvest time N levels in sweet corn leaves and seeds were independent of N doses and soil types. The highest sugar content in sweet corn was measured due to manure treatment, while low and high N doses tended to decrease it (*Table 1*).

Table 1. Total sugar content (g/kg) in sweet corn seeds after different N treatments

Treatment	Sand	Chernozem
Control	6.6	3.8
N60	4.4	2.6
N120 + manure	11.6	7.9
N180	4.4	6.3

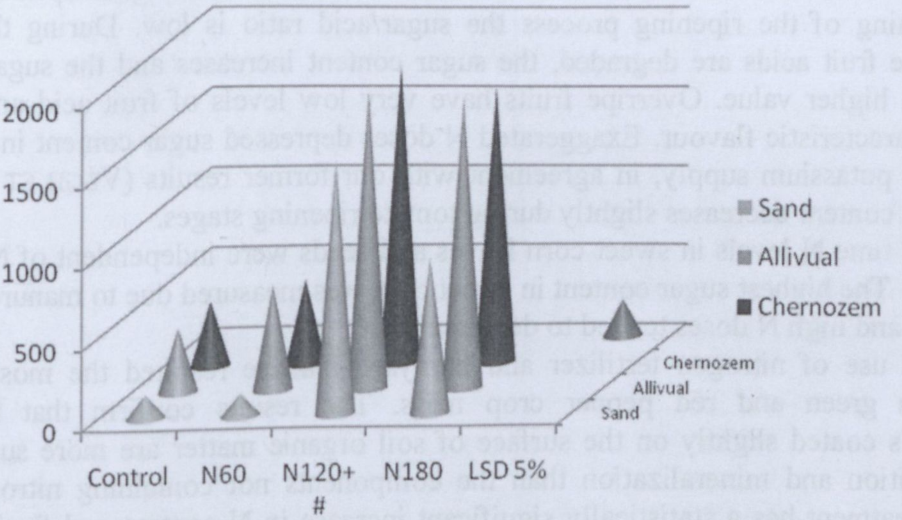

Figure 3. Changes in total crop mass of red pepper (g/lysimeter) after different N fertilizer doses.

The results of red pepper (paprika) crop mass are shown in *Figure 3*. The highest crop mass was reached by use of barnyard manure in alluvial soil. Red pepper powder quality was the best in the case of growing on alluvial soil (131 vs. 124 and 114 ASTA color value in alluvial compared to chernozem and sandy soil).

The examinations showed similar tendencies in the case of green pepper. Best total crop mass was reached after treatment with combination of NH_4NO_3 and manure. Final crop mass was 1869 and 1867 g/lysimeter compared to 1592 g/lysimeter in alluvial, chernozem and sandy soil.

CONCLUSIONS

In our four-year study period we investigated the effect of different soil types and nitrogen fertilizer doses, on crop mass and some chemical components of fruit and vegetative parts, in four test plants. Chernozem, alluvial and sandy soils are the three most common soil types in Hungary, significantly differing in structure, water reserving and nutrient supplying capacity etc.

N_{120} and N_{180} N doses increased crop mass statistically significantly in tomato test plants as compared to the control, in all soil types (SD5%), independently of the soil types. N_{60} and N_{120} kg ha^{-1} N fertilizer doses seemed to compensate for the differing nutrient supplier capacity of the examined soils. Nevertheless, increasing N dose to N_{180} kg ha^{-1} level resulted in increasing total crop mass only in alluvial and chernozem soils. This phenomenon may attract the attention to the better water dynamics and textural properties of these soils, compared to sandy soil. The crop yield enhancing effect of N fertilizer in sweet corn was also shown. Leaf examination results in tomato confirmed nitrogen translocation process. Leaf analysis in sweet corn showed decrease in N content in leaves from the beginning of the vegetation period till harvesting. This phenomenon calls attention to the importance of the time and place of leaf sampling, the age of plant, the position of leaf and nutritive capacity of the soil, so as to get correct diagnostic data.

Flavour characteristics of tomato fruit depend largely on the sugar and acid content of the berry. It is the sugar/acid ratio which contributes towards giving many fruit their characteristic flavour and so it is an indicator of commercial and organoleptic ripeness. At the beginning of the ripening process the sugar/acid ratio is low. During the ripening process the fruit acids are degraded, the sugar content increases and the sugar/acid ratio achieves a higher value. Overripe fruits have very low levels of fruit acid and therefore lack in characteristic flavour. Exaggerated N doses depressed sugar content in chernozem with good potassium supply, in agreement with our former results (VÉGH ET AL., 2007). Vitamin C content decreases slightly during tomato ripening stages.

At harvest time N levels in sweet corn leaves and seeds were independent of N doses and soil types. The highest sugar content in sweet corn was measured due to manure treatment, while low and high N doses tended to decrease it

Combined use of nitrogen fertilizer and barnyard manure resulted the most beneficial effects on green and red pepper crop mass. The results confirm that nitrogenous compounds coated slightly on the surface of soil organic matter are more susceptible to decomposition and mineralization than the components not containing nitrogen, so the manure treatment has a statistically significant increase in N content and final crop yield (BALIK ET AL., 2003)

In our experiments alluvial soil with high mold content proved to be the most suitable for growing red pepper. Our results emphasize the importance of the ecological growing circumstances in agricultural growing.

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REFERENCES

BALÍK J., ČERNÝ J., TLUSTOŠ P., ZITKOVÁ M. (2003): Nitrogen balance and mineral nitrogen content in the soil in a long experiment with maize under different systems of N fertilization Plant Soil Environment 49(12): 554–559.

KÁDÁR, I. (2007): Sustainability of soil fertility nutrient levels. Cereal Research Communications 35: 573-576.

NÉMETH, T. (2006): Nitrogen in the soil-plant system, nitrogen balances. Cereal Research Communications 34: 61-65.

SZILI-KOVÁCS, T., CSERNI I., VÉGH K. R., RAJKAI K., NÉMETH T. (2009): Fertilizer Effect on Carbon Dynamics of Different Texture Soils under Tomato Cultures. Communications in Soil Science and Plant Analysis 40: 840-849.

VÉGH, K. R., RAJKAI K., SZILI-KOVÁCS T., CSERNI I., NÉMETH T. (2007): Nitrogen efficiency in tomato culture, Cereal Research Communications 35: 973-976.