

Effect of nitrogen dressings to Jonathan apple trees in a long-term experiment

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Summary: During the last three decades, diverse effects of nitrogen application on the performance of apple trees were studied in field and pot experiments at the Experimental Station of University of Horticulture and Food Industry. The basic experiment, using different rates of nitrogen in kg/ha (check, N-50; N-100; N-200; N-400; and N-800), was carried out for a period of 13 years, thus including almost the whole bearing period of Jonathan apple trees on M.9 rootstocks.

The need of nitrogen in apple orchards on M.9 rootstock and soils with moderate humus content can be decreased considerably. Nitrogen application significantly increased leaf nitrogen and magnesium, but depressed leaf phosphorus and potassium content. With increasing doses of nitrogen fruit nitrogen content significantly increased and parallelly phosphorus and potassium content decreased. Even the lowest rate of nitrogen application decreased the red colouration of fruits. A direct negative correlation between nitrogen fertilization and fruit firmness was not proved. No close and significant correlation between fruit quality parameters and the nitrogen content in leaves, sampled at different dates, was revealed.

Introduction

In this century, studies on the nitrogen nutrition of apple trees have intensely been carried out by many researchers. During the last decades an impressive progress has been done in the better understanding of the effects of nitrogen supply to apple trees on the response of yielding and fruit quality. Since the 60s a rapid intensification in apple industry demanded a reevaluation of requirements in the nutrition of trees. The environmental aspects of nitrogen nutrition for apple orchards attract a particular interest regarding the possible nitrate pollution of soil and ground water.

N supply of apple trees has been a subject (of debate among scientist and growers for long. Faust, 1979; Delver, 1980; Titus-Kang, 1982; Fallahi and Simons, 1996; Fallahi, 1997. Sadowski et al., 1990 and Lipecki, 1990 found in their experiments that N-fertilization used only in moderate amounts affected positively the cropping of apple trees but a lot of orchard experiments on apple trees response to nitrogen applications were inconclusive.

Materials and methods

The experiment with different rates of nitrogen application had been carried out at the Szigetcsép Research Station of the University of Horticulture and Food Industry during a 13 year-long period. Climatic conditions in this region are characterized by high temperatures in July and August. The annual rainfall fluctuated around 550 to 600 mm and the average sunshine was from 1900 to 2100 hours a year.

The variety used in this trial was 'Jonathan' on M9 rootstock at a spacing of 4.0x2.0 in. The training system was free spindle. The experiment was arranged in randomised block design with six treatments and six replications in each. The soil was a Danubian alluvial sandy loam with medium humus and high content of P205 and K20.

The experiment, using different rates of nitrogen, in kg/ha (check, N-50; N-100; N-200; N-400 and N-800), was carried for a period of 13 years.

Yield, trunk circumference and alternation index by Hoblin (1936) were classified. Leaves were sampled three times a year: (1) at the stage of fruit development with diameter 10 to 12 mm; (2) at the end of July; (3) at harvest time. Fruit samples were collected at harvest time. Leaf and fruit samples were analysed for N, P, K, Ca and Mg content in the Central Laboratory of the University of Horticulture and Food Industry. Quality parameters and chemical composition of apples were also determined.

Results

The most important selected results of our 13 year-long experiment with nitrogen applications are presented in Tables 1–3.

The main conclusions in studying the nitrogen supply of 'Jonathan' apple trees on M9 rootstock are as follows:

- Under the soil conditions with moderate humus content, the nitrogen application increased the yield in most of the years, but the yield increase was significantly the highest by the most moderate rate of

Table 1 Average data of a 13 year-long experiment with "Jonathan" apple trees on N-applications

| Treatment | Yield t/ha | Alternation index | Trunk circumference mm | Fruit weight g | Red colouring % | Fruit firmness at harvest N/cm ² | Soluble solids at harvest |
|-------------|------------|-------------------|------------------------|----------------|-----------------|---|---------------------------|
| Check (No) | 35.88 | 10.82 | 131.24 | 115.3 | 61.97 | 73.6 | 12.6 |
| N 50 kg/ha | 39.91 | 12.38 | 135.28 | 110.2 | 45.81 | 72.8 | 12.5 |
| N 100 kg/ha | 38.37 | 14.00 | 136.75 | 115.8 | 47.63 | 73.7 | 12.7 |
| N 200 kg/ha | 39.39 | 13.65 | 135.31 | 112.9 | 48.57 | 72.9 | 13.0 |
| N 400 kg/ha | 37.09 | 18.22 | 135.31 | 110.1 | 46.33 | 73.9 | 13.1 |
| N 800 kg/ha | 32.49 | 20.41 | 119.96 | 113.9 | 52.13 | 72.8 | 13.6 |
| LSD 5 % | 1.67 | – | 8.52 | 3.9 | 6.10 | N.S. | 0.14 |

Table 2 Average leaf macroelement contents and ratios of "Jonathan" apple trees in a 13 year-long experiment on N-applications

| Treatment | Nutrient element (% d.m.) | | | | | Nutrient element ratios | | | | |
|-------------|---------------------------|------|------|------|------|-------------------------|------|------|------|------|
| | N | P | K | Ca | Mg | N/P | N/K | N/Ca | K/Ca | K/Mg |
| Check (No) | 2.17 | 0.17 | 1.39 | 1.41 | 0.40 | 14.26 | 1.60 | 1.63 | 1.07 | 3.23 |
| N 50 kg/ha | 2.29 | 0.14 | 1.15 | 1.45 | 0.45 | 18.03 | 2.02 | 1.68 | 0.85 | 2.34 |
| N 100 kg/ha | 2.41 | 0.14 | 1.22 | 1.35 | 0.45 | 19.02 | 2.02 | 1.88 | 0.98 | 2.53 |
| N 200 kg/ha | 2.37 | 0.13 | 1.16 | 1.37 | 0.45 | 19.58 | 2.08 | 1.83 | 0.90 | 2.30 |
| N 400 kg/ha | 2.40 | 0.14 | 1.04 | 1.42 | 0.46 | 18.02 | 2.41 | 1.80 | 0.77 | 1.89 |
| N 800 kg/ha | 2.39 | 0.15 | 0.95 | 1.47 | 0.50 | 17.54 | 2.65 | 1.73 | 0.68 | 1.67 |
| LSD 1 % | 0.08 | 0.03 | 0.09 | 0.08 | 0.52 | 1.69 | 0.22 | 0.11 | 0.06 | 0.28 |

Table 3 Average macroelement contents and ratios of Jonathan apples in a 13 year-long experiment on N-applications

| Treatment | Nutrient element (mg/100 g fresh weight) | | | | | Nutrient element ratios | | | | |
|-------------|--|-------|--------|------|------|-------------------------|------|-------|-------|---------|
| | N | P | K | Ca | Mg | N/P | N/K | N/Ca | K/Ca | K+Mg/Ca |
| Check (No) | 38.46 | 10.14 | 130.04 | 4.70 | 4.12 | 3.79 | 0.30 | 8.17 | 27.64 | 28.52 |
| N 50 kg/ha | 44.54 | 9.42 | 119.05 | 4.94 | 4.26 | 4.73 | 0.37 | 9.02 | 24.11 | 24.98 |
| N 100 kg/ha | 48.71 | 8.55 | 104.94 | 4.80 | 4.07 | 5.70 | 0.46 | 10.15 | 21.88 | 22.73 |
| N 200 kg/ha | 51.26 | 7.63 | 111.99 | 5.13 | 4.21 | 6.72 | 0.46 | 9.99 | 21.82 | 22.64 |
| N 400 kg/ha | 52.55 | 7.72 | 103.90 | 5.46 | 4.58 | 6.81 | 0.51 | 9.63 | 19.04 | 19.88 |
| N 800 kg/ha | 52.60 | 7.01 | 96.23 | 5.51 | 4.78 | 7.50 | 0.55 | 9.54 | 17.45 | 18.32 |
| LSD 1 % | 1.77 | 0.65 | 4.70 | 0.12 | 0.22 | 0.44 | 0.02 | 0.42 | 0.73 | 0.74 |

nitrogen (50 kg N/ha). Regarding the yield responses of 'Jonathan' apple trees it may be concluded that the need of nitrogen in apple orchards on M9 rootstock and soils with moderate humus content may be considerably reduced. It is presumed that an effective recirculation of nitrogen through organic matter returned to the soil occurs in apple orchards. Apparently, under average soil conditions, nitrogen requirements of apple trees may be met with a dose equal to single or double quantity of nitrogen removed by the fruits.

– The yearly alternation of crop was not decreased by increasing the nitrogen application. On the contrary, crop alternations between years were increased by the

nitrogen doses.

– Nitrogen applications significantly increased leaf nitrogen and magnesium, but depressed the phosphorous and potassium content. Effect of nitrogen treatments on the Ca-content of leaves was not distinct in most of the years.

– The adequate nitrogen levels in Jonathan leaves were as follows:

– 2.6–2.7% at the stage, when fruits reached 10 to 12 mm in diameter

– 2.2–2.4% at the end of July (standard sampling period)

– 2.0–2.1% at harvest time

– With increasing doses of nitrogen application the

nitrogen content in apples significantly increased and parallelly phosphorous and potassium content in fruits decreased. The increased N/P ratio in apples may be regarded as one of the possible negative effects of increased nitrogen application.

- Nitrogen treatments did not significantly increase the average fruit weight. The fruit load of 'Jonathan' apple trees affected the fruit size and weight rather than the nitrogen fertilization.
- Even the lowest rate of nitrogen application decreased the red colouration of fruit skin. This undesirable effect was consistent with all nitrogen treatments.
- At harvest time a slight effect on fruit firmness was observed as a result of nitrogen application. Our experiments (did not prove the wide-spread opinion that there is a direct negative correlation between nitrogen fertilization and fruit firmness.
- As regards the chemical composition of apples, the only close relationship was found between nitrogen applications and total acid content of the fruits. All nitrogen doses decreased the total acid content of apples.
- There was not close and significant correlation between fruit quality parameters and nitrogen content of leaves taken in different sampling times.
- Under the Hungarian continental climate conditions the vegetation seasons have greater effect on fruit quality than nitrogen application.

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