N:K ratio and its effect on paprika yield and quality in hydroculture

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Summary: Earlier results of experiments with paprika grown in soil have shown the high sensitivity of the crop to nutrient supply. According to these findings, yield and also fruit quality are highly affected not only by the nitrogen and potassium level, the concentration of nutrient solution, but also by the nitrogen-potassium ratio. Our preliminary tests have also proved, that the composition of the nutrient solution, first of all, the N/K ratio has a definite effect on the yield quantity and quality. Therefore we have investigated the ratio of the two nutrients with the aim of developing a nutrient solution of optimal composition for white fruited paprika forcing. The most balanced burden of the plants was found when the N/K ratio was 1:1. The highest yield was produced with N/K 1:1.3. Significant yield reduction (30%) was found with the treatment N/K 1:1.9 as compared to the 1:1.3 and 1:1.6.

Key words: paprika, nitrogen, potassium, yields quality, soilless cultivation, hydroponics, vitamin C

Introduction

Hydroculture of crops started in Hungary around in the early nineties. Nowadays, more than 100 hectares are utilised this way. After some commercial enterprises of several hectares, minor horticultural farms of 5–10.000 m^2 forcing area began to fit out their plastic covered greenhouses for the cultivation on rockwool, and there were also numerous modern blocks built expressly for hydroculture. Production technologies developed in Denmark and the Netherlands have been adopted. The fertiliser solution formulas applied in cucumber and tomato forcing had been developed abroad. However, no technology had been available for the hydroculture of white-fruited paprika, which is the main crop in Hungarian vegetable forcing, while in Western Europe, where the hydroculture had been developed, mainly blocky-type paprika has been cultivated. The environmental demands of this type are different from those of white-fruited paprika in many respects. We had to start mainly from our own experience in determining the concentration and the composition of the nutrient solution.

The nitrogen content of the paprika fruit is 20–30 mg in 100g of dry matter (1). When nitrogen content is appreciably lower, deficiency symptoms may be expected (symptoms of chlorosis on the bottom leaves, thin fruit wall, yield loss, etc.). On the other hand, the paprika plant is very sensitive nitrogen overdosage: the leaves turn dark green, fruit set is poor and blossom end rot appears (2).

The potassium content in paprika is almost the double of the nitrogen content (26–48 mg). Its deficiency causes serious chlorosis, increased inclination to diseases and fruit deformation (3,4). Vorwerk (5) has pointed out a cloze negative correlation between the nitrogen supply and the potassium uptake of the plant: increased nitrogen doses diminished the potassium content in the leaves and vice versa.

Increased nitrogen and potassium level diminish the calcium content of the plant, followed by severe deficiency symptoms (6,7).

The unfavourable composition of the irrigation water (i.e. the high salt and hydrocarbonate content) makes the hydroculture difficult in Hungary, especially in case of the salt sensitive paprika. Thus, the preparation of good nutrient solution requires not only the proper setting of the N/K ratio but also the desalting of the irrigation water, which is a very expensive operation and difficult to realize, taking into consideration the actual farm sizes (8).

Fruit quality including the taste, flavour substances and vitamin content will play an increasing role in the competition on the market in the forthcoming years. The composition of the nutrient solution affects the formation of these substances (9,10,11). The study of the influence of the nutrient solution composition on the alimentary value of the crops has been an essential aim of our research, too.

Material and method

The experiments related to nitrogen and potassium content of the nutrient solution used for paprika forcing on rockwool have been carried out on 0.6 hectares in a Venlo-type glasshouse of Szentes Kert Ltd. Co. at Szentes (the most significant vegetable forcing area in Southern Hungary). The glasshouse climate (temperature, humidity) has been regulated as a function of light and force of wind on the basis of a Dutch software.

The tests were made with 'Hó F_1', a conical white formed paprika variety trained on support. Seed was sown into small rockwool blocks on 28th September 2000, and the seedlings were transplanted into large blocks on 10th October. 3.5 plants per square metre were set to their final place in the glasshouse on 30th October and formed to two terminal shoots.

Each plant had 1.6 litres of rockwool. That means 1.12 litre /plant nutrient solution when the moisture content of the medium is 70 per cent.

Measurings were made with 70 plants in two different places in the greenhouse.

The N/K ratio was in the basic solution 1:1.3 (marked as control). This had been modified with NH_4NO_3 and K_2SO_4 solutions to 1:1 (A), 1:1.6 (B) and 1:1.9 (C), respectively in the different treatments.

The following parameters had been recorded:
The size of the leaf beside the flower nearest to the apex,
The distance between the opening flower and the apex,
The distance between the fruit set and the apex,
The number of fruits at,
The number of semi developed fruits,
The weight and the number of the 1st, 2nd and the 3rd class fruits,
The vitamin C content of the fruits the TOC content of the fruits,
The potassium content of the fruits.

Analyses of the nutrient solution were made five times during the vegetation period of the plants (at start, on 14. 04., 21. 04., 28. 04. and 05. 05. 2001) *(Table 1)*. Dry matter content, water-soluble organic matter content (TOC) and water-soluble potassium content were determined from 50g of raw sample after slicing and milling. Vitamin C content was determined from 10 g of raw sample with sand and phosphoric acid added, according to Spanyár-method.

Results and discussion

The vegetative parts of the plants have not been significantly affected by the different N/K ratios in the nutrient solution. The size of the leaf area (length and surface of the leaf beside the flower nearest to the apex, the number of the leaves) has not changed. However, the distance between the blooming flower and the apex – a feature characterising the length, growth and the habitus of the plant – has been smaller and the burden plants have been more compact. The number of ripe fruits, developing fruits, and number of flowers in blossom may describe the burden of the plants.

Till the 5th week, the most balanced burden was found on the plants grown with the solution A *(Figure 1)*. From the 5th week the highest yield was found in treatment B, and the poorest fruit setting in treatment C.

The increased potassium content of the nutrient solution has modified the yield. The highest yield and the lowest proportion of poor quality paprika fruits (2nd and 3rd class) have been found in the control treatment. However, no significant differences have been found in total yield and in grading of the crop between the treatments A, B and the control. On the other hand, considerable decline (on 5 per cent failure level) in yield and quality has been found in treatment C. The yield was 30 per cent lower than in the control and in treatment B. The low total yield was due to the decrease in the quantity of 1st class fruits *(Figure 2)*.

Several factors of the alimentary value of the fruits have changed, too, in consequence of the increased potassium-nitrogen ratio in the nutrient solution. The vitamin C, potassium and dry matter content of the fruits increased with the nutrient solutions higher in potassium *(Figure 3 and 4)*. The increase in vitamin C and dry matter content measured in our experiment agrees with the results of experiments carried out on soil substrate by several authors (12). In our earlier experiments, however we have not found any increase in the potassium content of the fruits (13).

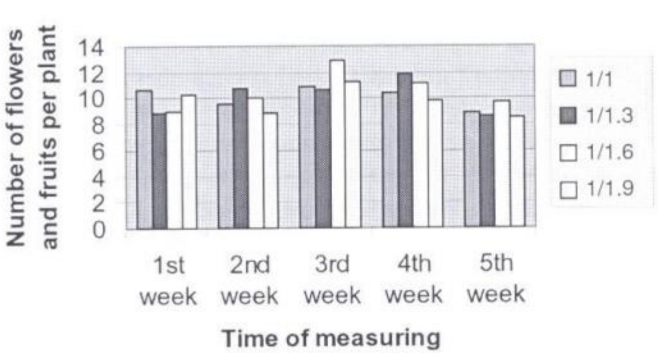

Figure 1 The burden of the plants as affected by the N/K ratio in the nutrient solution

Table 1 Results of the nutrient solution analyses in case of N:K ratio 1.0:1.0

1.0:1.0	pH	EC mS/cm	N mg/l	P mg/l	K mg/l	Ca mg/l	Mg mg/l
03.28 standard	5.8	2.8	251	45.89	345.16	176.85	44.3
15th week	6.49	2.85	276.4	34.1	281.5	165.1	43.4
16th week	6.38	2.69	333	40.6	355.8	177.2	53.9
17th week	6.64	2.41	198.1	42	222.3	141.5	61.9
18th week	6.18	2.13	201.5	31	205	181.1	40.5

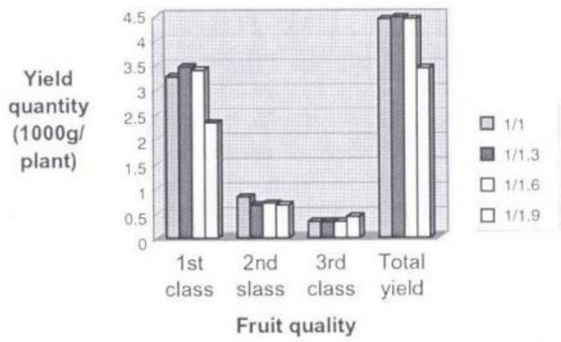

Figure 2 The effect of the N/K ratio in the nutrient solution on yield

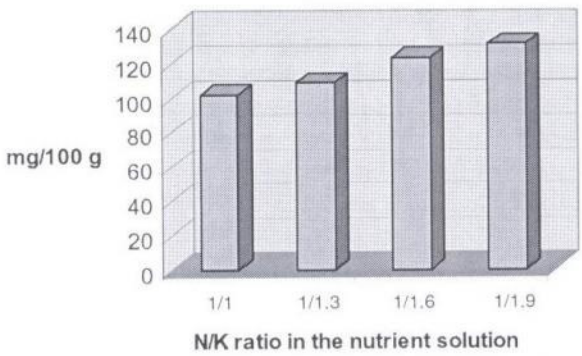

Figure 3 Vitamin C content of the fruits as a function of the N/K ratio in the nutrient solution

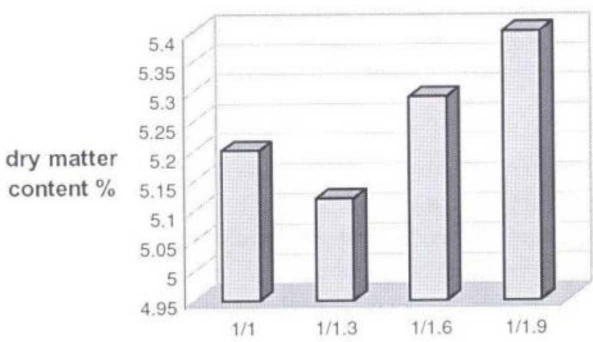

Figure 4 The dry matter content of the fruits as a function f the N/K ratio in the nutrient solution

Table 2 Results of the nutrient solution analyses in case of N:K ratio 1:1.3

1.0:1.3	pH	EC mS/cm	N mg/l	P mg/l	K mg/l	Ca mg/l	Mg mg/l
03.28 standard	5.8	2.8	251	45.89	345.16	176.85	44.3
15th week	6.77	2.53	218.1	36.8	293.3	183.7	44.9
16th week	6.47	2.02	221.4	38.8	334.3	159.6	48
17th week	6.54	1.98	238.2	39.4	340.2	136.8	52.6
18th week	6.19	2.25	228.1	32.8	328.4	196.2	41.9

Table 3 Results of the nutrient solution analyses in case of N:K ratio 1.0:1.6

1.0:1.6	pH	EC mS/cm	N mg/l	P mg/l	K mg/l	Ca mg/l	Mg mg/l
03.28 standard	5.8	2.8	251	45.89	345.16	176.85	44.3
15th week	6.91	3.31	269.7	36.8	465.9	181.4	56
16th week	6.29	3.22	259.7	54.1	431.7	191.2	64.5
17th week	6.67	2.04	179.8	44.3	320.6	167.7	52.3
18th week	6.85	2.17	218.1	25.4	324.5	174.5	44.2

Table 4 Results of the nutrient solution analyses in case of N:K ratio 1.0:1.9

1.0:1.9	pH	EC mS/cm	N mg/l	P mg/l	K mg/l	Ca mg/l	Mg mg/l
03.28 standard	5.8	2.8	251	45.89	345.16	176.85	44.3
15th week	6.76	3.2	169.8	38.1	402.7	169.8	51.4
16th week	6.61	3.48	231	38.8	461.4	166.7	53.9
17th week	6.56	2.15	161.5	68.9	369.2	161.1	54.7
18th week	6.19	2.62	208.1	32.4	404.4	186.8	46

The effect of the elevated potassium level in the soil or in the substrate has been measurable in the lower leaves, rarely in the upper ones. The differences in the potassium content of the fruits were results of potassium deficiency or overdosage merely in very extreme cases, when symptoms of acute deficiency or poisoning were also being observable on the plants.

Conclusions

The Nitrogen /potassium/ ratio in the nutrient solution exerts an influence on the development of the paprika plant. The results of our experiments have supported this statement by the following:

The most balanced burden of the plants was found when the N/K ratio was 1:1.

The highest number of fruit set was found on the plants grown with the nutrient solution N/K 1:1.6. The poorest fruit setting occurred with N/K 1:1.9.

The highest yield was produced with N/K 1:1.3.

Significant yield reduction (30%) was found with the treatment N/K 1:1.9 as compared to the 1:1.3 and 1:1.6.

Increased vitamin C content and potassium content of the fruits was measured in the treatment with solutions of high potassium content. Similar tendency was found in the dry matter content.

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