Role of nutrient supply in yield increase and quality improvement of spice pepper

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Summary: Hungarian spice pepper powder is a unique product, a real *hungaricum* with its flavour and aroma compounds and seasoning effect. Its competitiveness with foreign spice peppers is ensured by its high biological value deriving from the specially Hungarian production and processing technology. Besides the traditional and highly manual labour intensive processing technology, there are some modern industrial technologies as well, where high quality can be guaranteed only by producing excellent base material (raw pepper pods). This is the reason which necessitates the rational development of the elements of the production technology, such as nutrient supply. Our objective was to offer a contribution to this aim by our trials in plant nutrition.

Experiments on the nutrient supply of spice pepper were set up in the 2003 growing season in order to decide whether yields and fruit composition parameters of pepper could be increased by means of increased K fertiliser doses with lower N:K ratios. Several forms of potassium were used, as well as applying microelement top dressings in the single treatments. It was found that the increase of N:K ratio from 1:1 to 1:6 did not increase yields, but resulted in higher pigment and dry matter content. Microelement top dressing had a yield increasing effect at each N:K ratio. Higher potassium doses did not accelerate ripening.

Key words: peat substitutes, transplant growing, expanded clay granules

Introduction

Flavour and aroma compounds of spice pepper, as well as its excellent seasoning effect have been known to humanity for many centuries. In Hungary, the spice pepper sector with considerable importance for the national economy is the result of a development over several centuries. It has been used as a domestic spice for almost 300 years, as a commercial article for 160 years and as an important export good for 100 years. Over this period, it has become means of living for tens of thousands and Europe-wide famous production zones have developed in the country. Characteristically, the sector produces considerable value on a small area. The growing area was ranging around 6000 hectares in the average of the last years; it is 6% of the total vegetable area. The amount of raw paprika fruit produced makes up 65000 tons per year. Spice pepper powder produced is used in 90% for human consumption, in 7% for medicines and in 3% for cosmetic purposes.

A short review of the literature

Spice pepper plants have high nutrient demands. In order to exploit the potential yielding capacity as fully as possible, one of the important requirements is an optimal development. Nutrients should be available in optimal amounts at proper time. Proper nutrient supply is important not only from the point of view of yield, but as a major contribution to quality. Fertilisation has influence on every quality parameter that is important for the processing industry, such as dry matter, pigment content, sugar content and seed:fruit wall ratio.

Specific nutrient demands of spice pepper were first defined by *Horváth & Bujk* (1934). According to them, spice pepper takes up 137 kg/ha of N, 27 kg/ha of P_2O_5, 141 kg/ha of K_2O from the soil to produce 10 tons of raw crop, corresponding to a 5.1:1:5.4 ratio. Somewhat different values are defined in the fertilisation guidelines of MÉM NAK (Plant Protection and Agricultural Chemistry Centre of the Ministry of Agriculture and Food Industry), which are 4.8 kg/t N, 1.6 kg/t P_2O_5 and 6.5 kg/t K_2O. These amounts correspond to a 3 : 1 : 4 ratio.

Nutrients are demanded in different ratios in the different phenophases. Nitrogen uptake has its maximum at the beginning of flowering, then after diminishing slowly, it almost stops at the end of the growing period. The highest value for phosphorous uptake can similarly be detected at flowering, with a subsequent but not significant decrease. The maximum of potassium uptake occurs at flowering, than absorption starts to diminish, while the level of magnesium shows the highest value during the period of ripening (*Márkus & Kapitány*, 2001).

The first, so-called critical phase of plant development (from flowering until first-set fruits reach 5–8 cm) takes place in June. In this period the plant will respond sensitively both to nutrient shortage and to excessive fertilisation. The second phase is that of maximal nutrient accumulation, lasting from the 5–8 cm stage of fruit development until the end of the growing period. This is the most intensive period of dry matter production (*Kapeller*, 1994).

The rate of nutrient accumulation depends on the method used for propagation and on the variety as well. As regards transplanted stands, it is nitrogen that plants accumulate in the highest quantities, followed by potassium and then by phosphorous. In direct sown stands it is potassium that is accumulated in the highest rate, then come nitrogen and phosphorous (*Mécs*, 1978).

Potassium has a beneficial influence on fruiting, increasing earliness. In case of deficiency, fruit size and quantity will diminish, while excessive application might make fruits more susceptible to blossom end rot, caused by the antagonism of K and Ca (*Somos*, 1981). Potassium plays an extremely important role in plant / water relations. It helps survive dry periods, generating high turgor pressure in the cells. It is an activator of a number of enzymes, thus improving photosynthetic activity. Potassium also increases the C vitamin content of pepper. It improves in general the stress resistance of the plant (*Ernst*, 1993).

In case of potassium deficiency, total and mineral N contents may increase, while the proportion of organic N will diminish as a result of the insufficient N/K ratio. Acting on the synthesis of the nitrate reductase enzyme, it has an influence on protein production. Therefore, in plants with K deficiency, the proportion of protein N will be reduced. That is the reason why the recent literature stresses the importance of an optimal N/K ratio.

As regards qualitative parameters, optimal K supply is generally accepted to ensure the

- adequate formation of aroma, flavour and pigment compounds
- increased sugar, vitamin and protein content of the fruit
- enhanced pigment production
- higher dry matter content of the fruit
- improvement of plant resistance to abiotic stresses, in particular drought and cold tolerance (*Terbe* et al. 2002).

Nevertheless, the use of potassium fertilisers has a low level in Hungary. While in West-European countries the N:K ratio, as calculated on the basis of the amounts of fertilisers applied, is 1:0.44, in Hungary this ratio is 1:0.2–0.25 (*Terbe*, 1999).

It was an aim of the trials to test the efficiency of the different K fertiliser rates at given nitrogen and phosphorous supply levels, in particular to study the effect on fruit quality.

As high K contents in the soil and in the plant might interfere with the uptake of other important elements, such as magnesium, calcium, therefore in certain treatments a magnesium containing K fertiliser (Patentkali) was applied, as well as a micro nutrient fertiliser.

Material and method

Trials were set up at the co-operative Kék-Duna at Fajsz, using *Kalocsai merevszárú 622*, a sweet variety with semi-determinate growth, in direct sown cultivation. The experiment comprised six treatments, each of them with four replications. The areas of the treatments were 1 hectare, and the 50 m^2 size test plots were selected within them.

After completion of soil tests, nutrient supply patterns of the treatments were elaborated, as included in *Table 1*.

Besides, each treatment was given 65 t/ha farmyard manure. Treatment 1. is considered as the control treatment, being the nutrient application practice of the co-operative itself. Top dressings were applied twice during the growing period. Plants received the first top dressing at the stage of 6–8 leaves in the form of Nitrosol in a 20 kg/ha N per treatment dose and treatments 2., 4. and 6. were also given Microtop in a 20 kg/ha dose. The second top dressing was carried out in the period of massive flowering. This time 33 kg/ha Kristallon yellow and in the case of treatments 2., 4. and 6. 20 kg/ha Microtop were spread. Fertiliser doses were applied into the root zone by means of a fertiliser applicator. As the growing season was very dry, in order to favour nutrient availability and uninterrupted plant development the stand was irrigated 13 times in 10–15 mm doses using a LINEAR sprinkler.

Measurements were made to establish the amount of fruits picked from the sample plots and the parameters of fruit composition at the moment of harvest and after 40 days after ripening in net bags. Qualitative indicators important to

Table 1 Nutrient supply patterns of the treatments

Treatment	Base (kg/ha) N	P_2O_5	K_2O	Additive	
1-Control	120	120	120 (K_2SO_4)	Nitrosol+Kristallon	
2	120	120	120 (K2SO4)	Nitrosol+Kristallon	Microtop
3	120	120	200 (K_2SO_4)	Nitrosol+Kristallon	
4	120	120	200 (K_2SO_4)	Nitrosol+Kristallon	Microtop
5	120	120	200 (Patentkali)	Nitrosol+Kristallon	
6	120	120	200 (Patentkali)	Nitrosol+Kristallon	Microtop

Active ingredient content of the top-dressings:
Nitrosol: 28% N
Kristallon yellow: 13% N, 40% P, 13% K + micro-nutrients
Microtop: 15% MgO, 31% SO_3, 1% B, 1% Mn
The potassium fertilizers and Microtop are the products of the Kali und Salz GmbH, the company, which patronized the experiment.

the processing industry were also determined, such as dry matter content and pigment content. Dry matter content was measured by the drying oven method and pigment content was determined by the modified Benedek method.

Results

Yield results

Harvest for each treatment from 4×25 m^2 plots was carried out by hand in the period of 14–20 September. Healthy fruits and those unsuitable for processing because of disease, blossom end rot or other reasons were picked separately. Yield results are reported in *Figure 1*.

It can be seen very well that the majority of the supplementary treatments resulted in positive effects as compared to the practice of the co-operative itself (treatment 1). The yield-increasing effect of the micro-nutrient fertiliser Microtop is observable for each treatment pair (1–2; 3–4; 5–6). Particularly striking is the difference for the treatments with lower nutrient supply and lower base fertiliser level of K (treatments 1–2), where it was over 10%. Higher K doses did not increase yields. No antagonistic effect was found even at higher K doses. The number of fruits with blossom end rot was not higher, so the potassium rates even as high as 200 kg/ha had not created any problems in Ca uptake. The application of K sulphate and Patentkali gave similar results.

Compositional parameters

Dry matter content of harvested fruits was examined at two moments. First after harvest, then followed by a 40 day after ripening. Results are shown in *Figure 2*.

The slight difference between the dry matter content at harvest and by the end of after ripening indicates the state of maturity at picking. It shows clearly that the fruits of the control treatment were well ripened and dry by the time of harvest on 23rd September, but had low dry matter content. Higher K doses (treatments 3.–6.), especially when applied in the form of patentkali, resulted in higher dry matter content at after ripening, though retarding the development of full maturity. Probably, if these fruits had been picked at a later moment, quality parameters would have reached higher levels. An excellent response was given also by treatment 2. (control + Microtop).

Sample quantities of the harvested fruits were put in finely meshed nets and stored. Samples were examined in laboratory for the pigment content of each treatment, both in the case of fresh fruits and a 40-day after ripening. Results are shown in *Figure 3*.

It was the control treatment(1) that reached the lowest pigment content. While it had relatively high pigment content at picking, not very much increase occurred during the after ripening. 5–10% higher pigment contents were registered for the treatments with higher potassium rates. The positive influence of Microtop is also detectable in the treatment pairs 1–2 and 5–6.

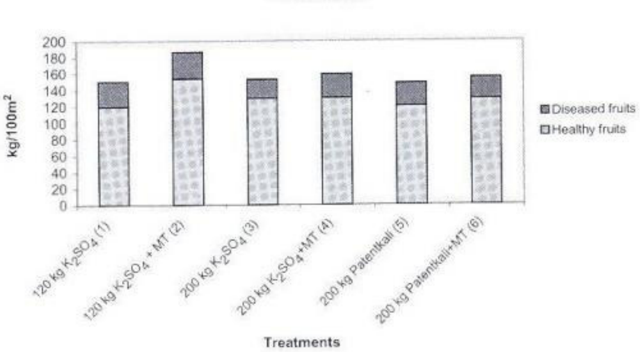

Figure 1 Accumulated yields according to the different treatments

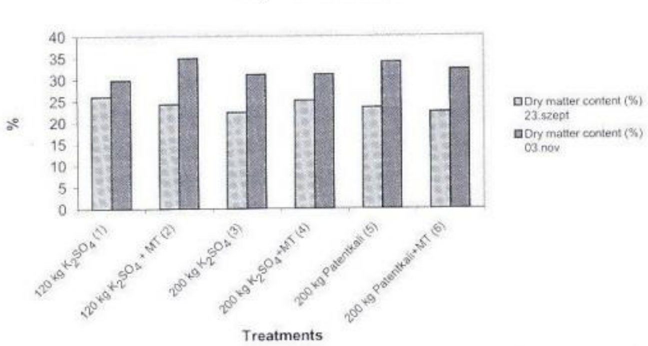

Figure 2 Dry matter content percentages of the fruits at harvest and at the end of after ripening

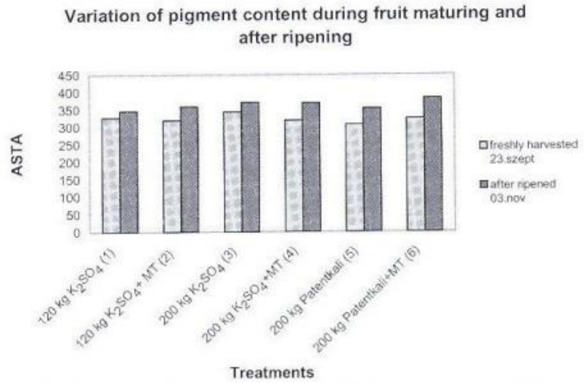

Figure 3 Pigment contents expressed in ASTA values at the moment of harvest and at the end of after ripening

Conclusions

As a result of the favourable season (temperature), qualitative parameters in spice pepper fruits showed favourable values. Results demonstrate that higher K doses did not lead to increased yields, but the influence on dry matter and pigment content proved to be beneficial. Contrasting to the findings reported in the literature, ripening was slightly retarded as a result, as shown by dry matter content values. No significant difference was seen between potassium applied in the form of potassium-sulphate and in that of patentkali.

Microtop top dressing gave higher yields in all of the cases, demonstrating to have a slight positive influence also on the increase of pigment content. This positive influence would have probably been more explicit if the treatments had not received Kristallon, which also included micronutrients.

These data are the first results of a series of experiments for several years and make only a small contribution to the nutrient supply system of spice pepper. In order to make the results more accurate further experiments and studies are necessary.

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