Yield and quality of vegetables in relation to potassium supply

(A káliumtrágyázás hatása a zöldségnövények termésmennyiségére és minőségére)

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INTRODUCTION

The vegetable sector plays a very important role in Hungarian agriculture. During the last decade, in terms of value, vegetable production gave 10-12% of agricultural plant production and it was steadily increasing.

The total vegetable production area comprises only about 2% of the total arable land, about 100 000 hectares (Table 1.), production amounts to approximately 2.5-3.8% of EU vegetable production.

Table 1. Harvested area of major vegetable crops in Hungary

		2001	2002	2003	2004	2005
Total		99 150	108 000	110 000	95 000	79 000
Open field		94 000	103 500	105 000	90 000	75 000
Main crops	Sweet corn	28 900	35 000	40 400	31 540	24 000
	Peas	18 900	20 700	17 500	16 000	14 500
	Watermelon	8 200	9 100	9 800	9 200	7 200
	Spice pepper	5 960	5 200	3 700	4 100	4 900
	Onions	6 000	5 070	4 250	4 400	2 600
	Sweet pepper	3 900	4 150	3 400	3 150	3 100
	Tomatoes	3 750	5 200	6 300	3 900	2 400
	Gherkin	3 250	3 800	3 200	1 500	1 000
	Carrots	2 800	2 900	2 900	2 850	2 500
	Beans	2 300	2 650	2 850	2 800	2 700
	Cabbages (white)	1 500	1 500	1 350	1 280	980
	Cauliflower	1 100	1 000	1 000	960	900

Out of the total 1.4-1.8 million tons, field production has a share of 75-80%, (Table 2.).and vegetable forcing comes to 400-450 000 tons per year. The export ratio is about 30% of the total vegetable production, out of which fresh exports constitute 7-9%, mainly coming from forcing, from protected production

Table 2. Total Harvested Production of Major Vegetable Crops in Hungary (1000 tons)

		2001	2002	2003	2004	2005
Total		1777	1950	2014	1853	1402
Open field		1328	1511	1596	1455	1045
Main crops	Sweet corn	423	535	618	540	375
	Peas	110	74	59	85	78
	Watermelon	148	185	243	208	167
	Spice pepper	55	52	26	30	23
	Onions	147	110	93	131	64
	Sweet pepper	53	69	48	50	42
	Tomatoes	118	149	236	136	71
	Gherkin	35	60	40	24	22
	Carrots	98	90	61	70	58
	Beans	18	18	21	20	14
	Cabbage (white)	60	51	44	45	33
	Cauliflower	22	15	17	15	14

What is the Hungarian vegetable production based on?

The country has excellent ecological conditions. The climate is suitable for field production of almost 100 different vegetable species

However, it must be taken into consideration that the country is located at the northernmost boarder for the field production of heat demanding vegetable species (such as tomatos, peppers, sweet corn, melons etc), whereas others, such as cabbages, leaf and root vegetables, peas, struggle with the warm continental summer climate.

The main vegetable species can be grouped as follows:

crops for processing: sweet corn, tomatoes, peas, beans, gherkin, peppers (spice pepper)

crops suitable for storing: onions, root vegetables (carrots, parsley, celeriac, red beet), cabbages (white cabbage, cauliflower, Savoy cabbage)

seasonal crops: table tomato, sweet pepper, cucumber, watermelon, melons, leaf vegetables, radish, Chinese cabbage, kohlrabi, mushroom

Vegetable products have different marketing channels:

- local markets share 15-20% of the total commerce. Their importance is still remarkable due to the traditions
- wholesale markets, of decreasing importance

- direct marketing to the supermarkets (such as Spar, Tesco, Metro etc.). This marketing channel shares 35-40% of the total commerce, but it is on a steady increase.

Hungary is self sufficient in vegetables, production exceeds 1.6 times domestic consumption. (This rate is 3 in the Netherlands, 2.44 in Spain, 1.78 and 1.84 in Italy and in Portugal.)

Against the excess in production Hungary has seasonal imports of fresh vegetables (tomatoes, cucumber, peppers in winter time, cauliflower, broccoli, carrots in summer time), and also of some processed products.

Exports make up a significant portion, approximately 30% of the total production is exported. The main crops for fresh export are sweet pepper, onions, garlic, mushroom, cabbages, watermelon, horseradish, gherkin, carrots and tomatoes.

Export is also seasonal, and owing to our climate Hungarian vegetable products can be exported in the period when field production, due to the hot summer, is over in Southern Europe.

Soil fertilization level

The use of fertilizers started in Hungary in the second half of the ‘50s. In the ‘70s and ‘80s, a well established network for soil analysis and advice was working under central direction. The soil analyses covered all the important parameters.

The last detailed soil survey effected in the second half of the ‘80s when fertilizer use was on the maximum, showed a rather satisfying situation as regards nutrient level of our soils. The state of supply with nitrogen was found medium or even higher in 73 percent, with phosphorus in 89 percent, with potassium in 83 percent of the soils. Less than 10 percent of the soils was poor in any of these nutrient elements.

In the late ‘80s Hungary was ranked among the leading countries in fertilizer consumption.

The nutrient balance of our soils

The nutrient balance of the soils well characterizes the level of agriculture in a country. In spite of this, they give a reliable basis for the comparison between the nutrient supply in the ‘80s and ‘90s. As shown by the data, the deficit in the nutrient balance in the ‘90s - coming exclusively from the low level of fertilization - is just as much as the surplus in the previous years: 70 kg/ha (Table 3).

Table 3. The nutrient balance of hungarian soils

	1986-1990			1991-2005		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Taken up by the crop	88	40	70	83	32	79
Supplied						
with commercial fertilizers	93	47	58	29	4	4
wtih by products	8	4	27	7	3	24
with farmyard manure	13	13	27	12	12	23
with pulses	5	0	0	5	0	0
Total supply	119	64	112	53	19	51
Balance	31	24	15	-30	-13	-28

The agrochemical respects of vegetable growing

For a true survey of the situation of fertilizer application *in the **field vegetable growing,*** the plants grown in combined field crop rotations (green peas, beans, onions, red peppers, tomatoes for processing) must be considered separately from the crops grown in irrigated vegetable crop rotations. In the group mentioned first, the tendencies are the same as with field crops: declining soil nutrient content, extremely low fertilizer consumption, one-sided nitrogen fertilization practically without using potassium and phosphorus. As compared to this, in the irrigated vegetable crop rotations more fertilizers are used, and, in general, the balance cannot be regarded as negative. It must be mentioned, however, that vegetables are privileged in the combined rotations, as the farms make efforts to meet first the nutrient demands of the vegetables that are of higher production value than the field crops (wheat, barley, corn, fodder crops).

In the vegetable crop rotations, mainly in the rather small market growers' farms, fertilizer application in the '90s diminished to a lesser degree than in the combined rotations where vegetable crops were grown mainly on large scale. The farmers are striving to maintain the nutrient level of the soil even at the expense of rentability, however, this is true for the nitrogen supply mainly. Another disadvantageous factor is the more and more diminishing application of barnyard manure, coming from the decrease in the livestock. It has a deleterious effect on the quality and the yield of the vegetables belonging to the organic manure demanding row crops that must be grown on soils of excellent structure.

In intensive vegetable growing a remarkable change has been observed recently. With the general spreading of drip irrigation, more and more growers have made use of the compound and complex fertilizers meeting much better the demands of the plants as regards nutrient element composition. As a consequence of the relatively high income and the quick

returns much more chemical fertilizers and organic manure are used. The soils are well supplied, in some cases lavishly supplied with nutrients.

Regarding the critical situation in crop production from the viewpoint of agrochemistry, one can state in general that circumstances in vegetable growing are somewhat better, however , there is a serious deficit in the nutrient balance, particularly in phosphorus and potassium in this branch, too.

The effect of potassium on the yield and on the quality of vegetables

The potassium demand of the several vegetable species is highly different. The potassium consumption of a vegetable culture depends on the specific potassium demand of the given plant species, on the cultivation conditions and on the soil type. One can state in general that horticultural crops, including vegetables, use up potassium much above the average for developing the crop.

In vegetable growing potassium is effective as plant nutrient in three different ways:

- *It increases the yield.*
- *It helps in achieving steady yields by improving.*
- *It improves crop quality.*

Potassium accumulates first of all in the vegetative plant organs. Consequently, in several vegetable cultures - as opposed to cereals and some other field crops - potassium does not get back to the soil after the harvest, but it is removed with the crop (for example with cole crops, salad crops, root vegetables, potatoes a. s. o.). Owing to the fact that potassium is accumulated in high quantities in the vegetative plant organs, the amount of potassium taken up particularly by these crops (and by other vegetables, too) greatly depends on the yield. For example, K_2O taken up by cole crops may range from 120 kg/ha to 280 kg/ha (by early cabbage and autumn/winter cabbage for storage, respectively). In a species of high potassium demand, the varietal differences may be higher than the differences between the individual vegetable species. The potassium demand of the single vegetable crops, as a function to yield, is shown in

Potassium fertilization in vegetable growing, with special respect to crop quality

The fertilizer dose to be delivered is calculated as follows: the expected yield multiplied by the potassium quantity needed for the production of unit crops (Table 4) and corrected as a function of the degree of supply with potassium in the soil.

Table 4. The potassium demand of vegetable crops

CROP	Yield (mt/ha)	Potassium demand (K_2O kg/ha)
Tomato	30-50	200-300
Pepper	15-25	105-175
Green pea	4-6	90-135
French bean	10-14	200-280
Cucumber	30-40	90-120
Melon	20-30	190-280
Carrot	40-50	240-300
Parsley	10-20	80-160
Garden beet	10-20	80-160
Celeriac	20-30	130-195
Radish	10-20	80-160
Lettuce	15-25	90-150
Onion	15-25	70-120
Garlic	10-20	70-140
Cauliflower	15-25	130-220
Cabbage	60-70	120-280

Because of the high amounts required and the continuous, balanced potassium demand of the vegetable crops the whole fertilizer quantity to be applied must be portioned. In addition to basic fertilization, starter and top dressing is necessary in long season cultures. Potassium given as top-dressing has a favourable effect on the keeping quality of cabbage and savoy, on the colouring of tomatoes and peppers. Besides improving the storability and the sugar content of carrots, several authors say that it hinders the accumulation of nitrates by counterbalancing the effect of nitrogen. In cucumbers, potassium helps the plants to renew their vegetative and generative organs. In order to avoid salt risk, the dose given as basic fertilizer mustn't exceed 200 to 300 kg/ha, the single doses of starter or top dressing 100 to 150 kg/ha. The higher values apply to crops moderately sensitive to salt (e.g. cole crops, tomato), the lower ones apply to salt sensitive cultures (e.g. lettuce, carrot, cucumber, pepper).

The commercial fertilizers may be classified as sulphates, nitrates and chlorides. The distinction is particularly important in vegetable growing since the accompanying substances may exert favourable or adverse effects on the vegetable crops. Contrary to field crops, most

vegetables are sensitive to chlorides, with the exception of the group of root crops, however, celeriac must be mentioned separately as it prefers the fertilizers of sulphate type. In intensive vegetable growing, the use of sulphate type may be suggested for basic fertilization because of the relatively low price. When drip irrigation is practised, preference has to be given to the perfectly water soluble potassium nitrate for feeding during the cultivation period.

Conclusions

Besides increasing the yield, potassium improves the quality of vegetables in several aspects, such as the chemical composition, the marketability and the storability of the crop. As is to be expected, these properties will be of growing importance under the ever harder market conditions, maybe, they will be of decisive importance. Consequently, some elements of the production technology, like potassium fertilization, will come into prominence.

While mineral fertilizer application compared on the basis of the N / K ratio is 1 : 0.44 in the West-European countries, the ratio is 1 : 0.2 to 1.0 : 0.27 in Hungary and in the neighbouring countries. This is rather unfavourable for the quality of the potassium exacting horticultural crops, including the vegetables.

Before long, not only the quantity of the fertilizers applied but other factors increasing the effectivity of nutrient supply, e. g. method, timing, fertilizer form, too, will be essential conditions of being on the market with our products.

In the future, only reasonable and efficient nutrient supply may enable us to compete with the cheap produce of excellent quality from Spain, Italy and North Africa. Moreover, our farmers will be compelled to the most efficient use of the mineral fertilizers by the increasingly strict regulations on environmental protection as well.