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Production and quality of fennel

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Abstract. Changes in our life conditions require healthier nutrients of vegetable origin which are rich in vitamins and fibres. Fennel seems to be suitable as it contains sweet, aromatic volatiles, vitamins A, B, C, P and anethole. In horticulture, the production of exotic, hardly known crops, like fennel, should be taken into consideration. Our farm trials in 2009 proved unambiguously that acceptable yield can be obtained even under adverse weather conditions. In the tuber of fennel (Váza and Tauro varieties) the percentage of macro-, mezzo- and micro-elements was found to be between those of the root and the foliage. In the tuber 30-52% of N, P, K was found.

Keywords: macro-, mezzo- and micro-elements of fennel, anethole

1 Introduction

On the threshold of the 21st century horticulture, similar to numerous other spheres, needs changes in our general attitude to life. Our joining the European Union challenged Hungarian growers. Exotic or hardly known crops like, fennel, could be introduced considering, of course, research and empirical experiences as expressed by Lajos Kreybig in the middle of the past century: "every crop should be cultivated according to its requirements." That means,

efficient farming can only be carried on if local conditions are taken into account. The ecological conditions of Hungary favour fennel production.

In 1980 at the Vegetable Crops Research Institute Imre Cserni started research on introducing and working out cultivation technologies for an exotic (new) crop – cultivated in the Mediterranean region and well known in the western countries, but almost completely unknown in Hungary. Results involving three decades and made public at numerous conferences, congresses and in publications seem to bear fruit now.

Today attention is turning towards healthy nourishment. Changes in our attitude to life require more food of vegetable origin rich in vitamins and fibres and poor in fat. Such a vegetable could be the fennel [1, 2, 3, 4].

Fennel in the Mediterranean area

Foeniculum vulgare was cultivated and known by the ancient Greeks and Romans who attributed certain magic power to it. The name Foeniculum first appeared by Plinius. In Italy, Spain and France it was cultivated in the 14th-15th centuries. In France it was very popular in the 16th century and highly appreciated in the court of Louis XIV [4].

At present it has its renaissance. In numerous European countries it seems to gain popularity again. Cultivation is mostly concentrated on the Mediterranean area but it is well known in the Far East as well. In the Muslim countries it belongs to the staple vegetables, like cabbage in Hungary. That is quite natural as in the Muslim world alcohol is prohibited and such aromatic plants are consumers' goods.

In 1980 Italy produced 350000 t/year, France nearly 7000 t/year and Switzerland 3000 t/year [5]. In France mean consumption reached 0,5 kg/head. Today production is gaining ground in North-America, too. Production level is the highest in the Netherlands.

Botanical description

Fennel belongs to the family Apiaceae (Umbelliferae). It was taxonomically ranged by Keller et al. [in 5]. The root is white, spindle-like and deep penetrating. The stem is erect, cylindrical, green. The basic part of the peduncle is bulb-like thickened; it is the tuber (Fig. 1).

Inflorescence is double compound, umbel. Flowers are tiny, yellow.

Fruit is 4-5 mm long, 1-2 mm wide, elongated at the top, twin achene, greenish or light brown-grey. Thousand seed weight is 4-5 g.

Figure 1: Fennel

It requires warm and long day periods. However, there are variants which are indifferent to day length.

Every part of the plant contains sweet, aromatic volatiles [6]. Beside the tuber the foliage is also edible or can be used to decorate warm or cold dishes. Due to its anethole content it is used for soft and strong drinks. It has important physiological effects: stimulates appetite, digestion, intestinal activity, milk secretion, besides diuretic and carminative effects. The curative effect has been known since Hippocrates. Besides these favourable effects it can cause some flatulence. The cosmetics industry also shows interests.

In addition to sugar it contains considerable quantities of P and Ca, as well as A, B_1, B_2, B_5, B_6, C and P vitamins. Carotene and vitamin C contents are considerable. Seeds not usable for cultivation are used as bait by anglers. Foliage and stem residues are favoured by rabbits. In bio-farming root and stem residue compost is especially useful due to its favourable C/N ratio improving the recycling of organic residues. By-products on field (stem and foliage) are useful green manure. Their total N-content can reach 82.1% as related to air dry matter content [7].

Fennel is mostly cultivated for its tuber prepared in various dishes (Fig. 2).

Hungarian people prefer layered fennel (also layered savoy or cauliflower), or with mayonnaise [7, 8].

Figure 2: Different servings: layered, in Greek fashion, with mayonnaise

Leaves and roots can also be consumed fresh or dried [9].

The tuber can be blanched, deep frozen, dried or pickled [9, 10, 11]. No part of the plant should be discarded.

2 Materials and Methods

To test fennel quality 2 varieties Váza (of Cserni) and Tauro (Clause French Seed Company) were sown in the nursery garden of the Horticultural College in the spring of 2010. Roots, tuber and foliage (leaves + stem) were tested separately.

Total N-content was determined by Kjeldahl method (MSZ-08-1783-6:1983) and total P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu, B and Mo by ICP spectrometer (MSZ-08-1783-28:1985 and MSZ-08-1983-29:1985, respectively).

The data cited are based on farm trial results performed in Kaba at BonFreeze Co. in 2009. Prior to soil cultivation the nutrient supply of the soil had been tested to guarantee the proper supply of the crop according to requirements.

Fennel was grown on field A/1 of BonFreeze Co., on a loess ridge of Debrecen, a moderately heavy chernozem soil. One part of the field had good humus content, the other part was poor in humus. AL-P_2O_5 and K_2O contents were partly good and partly moderate. Following the nutrient uptake dynamics of the crop 400 kg/ha 8:20:30 Power fertilizer was applied as base. During the growing period 51 kg/ha N active agent (150 kg/ha ammonium nitrate) was given as side-dressing.

Seeds were sown on 1st July 2009 at 75-84 cm row and 10 cm plant distance, corresponding theoretically to 13 plants/m^2. This agrees with former research and farm experience and means 3 kg/m^2 yield in case of 250 g/plant marketable yield.

At present, however, the yield of marketable plants was unimportant as only the tuber (without stem residues), blanched and deep frozen was wanted by the costumer. It meant at least 25% less yield. The ideal marketable yield is 1.5-2.5 kg/m^2, in present case it meant 1.55 kg/m^2, that is 15.5 t/ha (without stem residues). During the growing period weather did not favour growth. During the growing period of 98 days mean temperature was 23.6°C with 74 mm natural precipitation. 300 mm had to be supplied by irrigation (water cannon). During the growing period hand hoeing was performed twice causing some loss of plants. Later hares damaged the crop. No plant protection was needed.

3 Results and discussions

Values

As found in former trials N and K fertilization increased the N and K % in every part of the plant. No considerable change was found in P while N and K surplus affected Na, Ca, Mg and Fe contents negatively. Increasing K doses diminished Na in plant parts. There was a negative correlation between K and Na contents in tuber [12, 13, 14].

According to present analytical data nearly half or even more of the N, Ca, Mg, Na, Mn, Zn, B and Mo contents accumulated in the foliage in both varieties, Váza (registered by Cserni) and Tauro (Clause) (Tables 1a, 1b, 1c, 1d and 2a, 2b, 2c, 2d) in agreement with literary data confirming that green plant parts (stem + leaves) represent best surplus or lack of nutrient elements.

In the tuber the percentage of macro-, mezzo- and micro-nutrients were between those of the root and the foliage. The tuber contained 30-52% of N, P, K (see Tables).

The poorest N, P, K, Ca, Mg, Na, Mn, Zn, B and Mo quantities were found in the root. On the contrary, the root contained the highest Fe content as also experienced by former tests [12, 13]. Present test showed similar results for Cu.

Table 1a: N, P, K content of plant parts of fennel variety Váza

Items	Mean green mass %	Váza						
		Solids g/100g plant*	Measured			Calculated		
			N	P	K	N	P	K
			m/m%			%		
Root	12	1.81	1.65	0.501	2.57	14	22	15
Tuber	52	3.43	2.59	0.616	4.72	41	49	52
Foliage**	36	3.05	3.18	0.412	3.37	45	29	33

*: air dry weight, g/100g plant of average size; **: foliage (leaves+stem).

Table 1b: Ca, Mg and Na content of plant parts of fennel variety Váza

Items	Mean green mass %	Váza						
		Solids g/100g plant*	Measured			Calculated		
			Ca	Mg	Na	Ca	Mg	Na
			m/m%			%		
Root	12	1.81	0.465	0.184	0.458	6	14	20
Tuber	52	3.43	1.070	0.276	0.423	29	37	32
Foliage**	36	3.05	2.730	0.403	0.694	65	49	48

Table 1c: Fe, Mn and Zn content of plant parts of fennel variety Váza

Items	Mean green mass %	Váza						
		Solids g/100g plant*	Measured			Calculated		
			Fe	Mn	Zn	Fe	Mn	Zn
			m/m%			%		
Root	12	1.81	183	17.2	17.5	46	9	9
Tuber	52	3.43	38.7	16.6	32.1	18	15	32
Foliage**	36	3.05	85.2	55.0	41.0	36	76	59

Table 1d: Cu, B and Mo content of plant parts of fennel variety Váza

Items	Mean green mass %	Váza						
		Solids g/100g plant*	Measured			Calculated		
			Cu	B	Mo	Cu	B	Mo
			m/m%			%		
Root	12	1.81	16.0	23.7	0.247	50	12	5
Tuber	52	3.43	32.3	33.9	0.318	43	31	12
Foliage**	36	3.05	7.60	41.9	1.630	7	57	84

Table 2a: N, P, K content of plant parts of fennel variety Tauro

Items	Mean green mass %	Tauro						
		Solids g/100g plant*	Measured			Calculated		
			N	P	K	N	P	K
			m/m%			%		
Root	12	1.44	1.75	0.425	3.66	11	14	12
Tuber	52	2.85	2.38	0.645	6.19	30	41	41
Foliage**	36	5.36	2.48	0,381	3.68	59	45	47

*: air dry weight, g/100g plant of average size; **: foliage (leaves+stem).

Table 2b: Ca, Mg and Na content of plant parts of fennel variety Tauro

Items	Mean green mass %	Tauro						
		Solids g/100g plant*	Measured			Calculated		
			Ca	Mg	Na	Ca	Mg	Na
			m/m%			%		
Root	12	1.44	0.541	0.240	0.342	4	11	15
Tuber	52	2.85	0.772	0.245	0.188	11	22	15
Foliage**	36	5.36	3.260	0.402	0.439	85	67	70

Table 2c: Fe, Mn and Zn content of plant parts of fennel variety Tauro

Items	Mean green mass %	Tauro						
		Solids g/100g plant*	Measured			Calculated		
			Fe	Mn	Zn	Fe	Mn	Zn
			m/m%			%		
Root	12	1.44	319	24.4	20.7	49	9	10
Tuber	52	2.85	36.6	15.3	30.8	10	10	25
Foliage**	36	5.36	73.3	62.1	38.8	41	81	65

Table 2d: Cu, B and Mo content of plant parts of fennel variety Tauro

Items	Mean green mass %	Tauro						
		Solids g/100g plant*	Measured			Calculated		
			Cu	B	Mo	Cu	B	Mo
			m/m%			%		
Root	12	1.44	55.9	22.0	0.213	34	7	2
Tuber	52	2.85	29.7	42.5	0.379	34	21	6
Foliage**	36	5.36	14.4	68.4	3.030	32	72	92

Cultivation

Fennel will never be an important crop in Hungary. Home consumption can be covered by home varieties.

Large-scale production (maybe for export) can only be recommended when reliable markets are available. In 2009 there was a chance in Kaba to compensate for sugar beet by fennel to secure work for local growers.

Adaptation may be a very important criterion for sustainable agriculture, that is, the accommodation to altered conditions in such a way as to preserve our values. Efforts should be made to utilize and take care of our fields to the best of our knowledge.

Production trials helped us learn the most important requirements of fennel. Suitable production technologies for the variety Váza were worked out by Cserni and coworkers [15]. Its requirements for nutrients, water and soil are almost entirely known as well as the ecological production possibilities and economy [16, 17, 18, 19, 20].

Under our climatic conditions, as stated by trials, end of June, beginning of July favour sowing. There is no danger of bolting as days are getting shorter. Harvest time begins in October, the growing period lasts for 90-100 days.

Fennel favours well cultivated soils of loose structure, free of hard pan [21, 22, 23, 24, 25]. It responds positively to bioproducts of high organic matter [15]. For an average yield (20 t/ha) 58-26-194 kg/ha N-P_2O_5-K_2O is taken up by plant parts above the ground. Depending on the nutrient supply of the soil it requires 80-120 kg/ha N, 70-100 kg/ha P (P_2O_5) and 120-160 kg/ha K (K_2O) active agents. P and K are applied as basic fertilizers. On sandy soils N loss can be considerable (40-70 kg/ha) and when irrigated frequently K can also be leached (10%) [25].

To reduce stress on environment on loose soils N can be applied as side-dressing in several portions. On moderately heavy soils N can be given in one portion. On neutral or slightly alkaline soils ammonium nitrate should be substituted by ammonium sulphate. Fennel tolerates monoculture as well as found by Cserni.

Considering a 95-105 day growing period field fennel production requires 200-350 mm natural precipitation or irrigation depending on soil type and soil water supply.

This requirement can best be satisfied by the cooler and rainier climate of Transdanubia.

The recommended area in direct seeding is 13 plants/m^2 (0.13 $\times$ 0.57 m). Denser or looser crops favour bolting in varieties sensitive to day length. Air

dryness can also cause negative effects hindering the development of tubers. Transplants are only recommended for second crops. Forcing is not dealt with in this article.

There are hardly any pests. Occasionally mole-crickets (Gryllotalpa gryllotalpa) and hares can cause some damage. No plant protection was needed.

Marketable I. class tubers have 250-350 g. Tubers of II. class are smaller but shapely and marketable. Elongated but still young tubers can be dried or pickled (2:2:4 % salt: vinegar: sugar). It can be stored at about 5°C for 50 days with 15-25% loss [10]. After blanching it can be kept frozen for 1-2 years.

Former approximative calculations gave 1 million Ft income for 1 ha fennel [19, 20].

Large-scale production experiences in 2009

The variety Tauro bred and propagated by Clause Seed Co. France was produced successfully for an Italian costumer by BonFreeze Co. on 1.7 ha in 2009.

Good results were obtained despite adverse climatic conditions (Fig. 3) due to the harmonized cooperation between research and production [26, 27].

Figure 3: Large-scale production of fennel

4 Conclusion

In horticulture, the production of exotic, hardly known crops, like fennel, should be taken into consideration. Our farm trials in 2009 proved unam-

biguously that acceptable yield can be obtained even under adverse weather conditions. In the tuber of fennel (Váza and Tauro varieties) the percentage of macro-, mezzo- and micro-elements was found to be between those of the root and the foliage. Good results were obtained despite adverse climatic conditions.

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