Korean J. Medicinal Crop Sci. 11(4) : 259 − 263(2003)

Characteristics of Morphological and Production from Different Origin of *Foeniculum vulgare* Mill.

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ABSTRACT : This study was carried out to get basic information about the morphological and production characteristics of fennel populations different origin under different ecological conditions in Hungary. The Korean population can be registered as a medium high genotype and showed a more accelerated growth characters than Hungarian taxon and the two populations have a medium homogeneity (CV = 4~22%). In the second year plant height in Hungarian taxon was significantly higher than that of the Korean population. The shooting dynamic of individual plants might be heterogeneous in both taxa and the Korean population was not only shorter in the height but had also less shoots by 16% than the Hungarian one. The Hungarian taxon exceeded the umbel size and numbers to the Korean one (by 3.62 cm in the average) and the variability in the populations was high (CV = 29~49%). Seed size was proved to be also a discriminative feature between the examined taxa. With small deviations (CV < 2) the Hungarian population produced seeds longer by 38%. Homogeneity in the populations was dependent more on the vegetation years and on the characteristics measured but less on the origins, respectively.

Key words : *Foeniculum vulgare* Mill. Apiaceae, different population, morphology, production, seed mass

INTRODUCTION

Fennel is one of the oldest herbs known for mankind and its advantageous flavour and medical effects were already known to the ancient Greeks and Romans (Hornok, 1992). The ancient Egyptians, Greeks and Romans usually added its aromatic fruits and succulents shoots to their dishes (Lestrange, 1977). Rosengarthen (1969) pointed out that fennel was the symbol of success in ancient Greece and also mentioned that fennel was hung over doors to ward off evil spirits in the middle ages. *Foeniculum vulgare* Mill. belongs to the Apiaceae family and the subspecies *piperitum* of *Foeniculum vulgare* can be morphologically distinguished from the *Foeniculum vulgare* by its leaves, which are lengthy and triangular in outline, and have rigid fleshly short lobes (Badoc & Deffieux, 1994). The fennel leaves are 3~4 pinnate, triangular, alternate, the lowest being the longest and on higher positions leaves become smaller and green. Fennel has a hollow stem with a characteristic smell solid and straight is erect, abundantly branched rounded and ash green in color (Hornok, 1992). The plant height of fennel depends on the subspecies and the growing conditions. The var. *dulce* is usually grows up to 80~100 ㎝ but bitter fennel *vulgare* is taller and may reach a height of 200~250 ㎝. The inflorescence of the *Apiaceae* species is a compound umbel and the sizes of fennel flowers is 1~2 ㎜ in diameter ; the size of the terminal umbels 4~12 ㎝ in

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Received February 17, 2003 / Accepted October 20, 2003.

diameter (Nemeth & Szekely, 2000). The chromosome number of *Foeniculum vulgare* was known to be diploid 2n = 22 (Koul *et al.*, 1996), but Jin & Sheng (1994) reported 2n = 12 by a modified traditional squash method. The dried fennel fruits are oval, greenish or yellowish-brown with prominent ridges, 6~10 ㎜ long, 2~3 ㎜ wide, cylindrical and twin academial, and they have a warm, sweet odour somewhat similar to that of anise. The mass of 1000 seeds is about 4~8 g. The fennel root penetrates into the soil and its shape is spindle like, bulky and colour is white (Hornok, 1992). Optimal temperature of fennel is 4~27℃ and likes warm conditions due to its Mediterranean origin, and it can not always survive the winter of central Europe (Hornk, 1992). The initial developmental phase of fennel is slow and requires 2~2.5 months from the period of germination to the emergence of the stem. In the temperate zone, flowering takes place from the end of July to late August in perennial stands, while it starts somewhat later in the first year (Peterson *et al.*, 1993). From flowering till ripening of the fruits it takes 5~6 weeks. The several lateral branches and usually high number of side-umbels, however cause fruit ripening uneven. The aim of our investigations were to get basic information about the morphological and production of different fennel populations under different ecological conditions in Hungary from 1997 to 1999.

MATERIALS AND METHODS

Two intraspecific taxa of *Foeniculum vulgare* subsp. *capillaceum* var. *vulgare* were used in our investigations. Hungarian bitter fennel cultivar cv. Soroksari (source from Gene bank of the Department of Medicinal anc Aromatic Plants, SZIE), which has officially been registered in Hungary since 1990. Fennel of Korean origin was grown as a local accession (source from Gene bank of the Rural Development Administration in Suwon, Korea). The seeds were sown in open field plots of 20 ㎡ with 3 replications in early April 1997. Row distance was 50 ㎝ and seed dose 8 ㎏/ha. The measurements and sampling were carried out for the vegetation cycle's populations from 1997 to 1999 for the two different fennel origins. The optimal plant development assured by regular mechanical weed control and irrigation in each year. During the ontogenesis, growth and development of each population at each year was investigated for the 10 individual plants according to the following. In the first vegetation cycle : plant height at 3 times (at the leaf rosette stadium, at the main umbel flowering and at the waxy fruit stage); the number of branches/shoot, number of nodes/shoot, number of umbels/plant, umbel diameter (secondary umbels, 5 pcs/plant) at the full flowering stage; lenght of the main root at the end of vegetation; fresh and dry mass of stem, leaf and roots/plant. Drying was carried out in shadow, without artificial heating. In the second vegetation cycle : plant height at 3 times (at the leaf rosette stadium, at the main umbel flowering stage and at the waxy fruit stage); the number of shoots/plant, number of branches/shoot, number of umbels/plant, secondary umbel diameter (5 pcs/plant) at the full flowering stage, seed lenght (25 seeds/sample) and one thousand seed mass (3×50 seeds/sample) after harvesting and natural drying of the ripen fruits (average sample). In the third vegetation cycle's morphological and seed production characters were investigated in the same conditions as the second vegetation cycles for each population excpept plant height, which was measured twice in before budding and before main umbel flowering. For each series of samples means and standard deviations wre calculated, furthermore the coefficient of varience (CV, %) was determined to evaluate the homogeneity of the two populations.

RESULTS AND DISCUSSION

One-year-old populations showed significant differences between the plant height at the end of the first vegetation period and at the time of harvesting in both taxa (Table 1), an height of the Hungarian cultivar exceeded that of the Korean one by 12.5% (16 ㎝). This divergence was not significant at former registration times. In investigations at the same growing place (Experimantal Station, Soroksar), Omidbaigi (1990) mentioned 153 ㎝, while Kattaa

(1996) measured 158 ㎝ as average values in the one-year-old Hungarian cultivar. The Korean population can be registered as a medium high genotype and showed a more accelerated growth than Hungarian taxon and the both populations have a medium homogeneity (CV = 4~22%). Plant height seems to be different as a consequence of the proportionally (by about 9%) less number of nodes in the Korean population not as a consequence of the shorter inter-nodes. The plants of Korean population also developed significantly less shoots (by 8.7%) than the hungarian cultivar. while the umber (43~47 pieces/plant) and size (diameter) of their umbels and size (10.3~10,9 ㎝ diameter) did not show significant differences, respectively. The shoot number of umbels showed a high variability with the CV values 36~52%. The length of the roots does not seem to be in correlation with the length of shoots. It was by 3.5 ㎝ longer in the Korean population but with no statistical significance. In the second year, Hungarian population already exhibited a stronger growth at the beginning of vegetation period (Table 2). Plant height was similar as Omidbaigi (1993) reported to be 189 ㎝, but did not reach the value of 230 ㎝ reported by Kattaa (1996). The plant height at each investigated plant was significantly higher than that of the Korean population. The variance was considerable and much higher in the one-year-old stands (Table 1). It was especially high at the beginning of the vegetation period. It was showed that the shooting dynamic of the individual plants might be heterogeneous. The Korean population was not only shorter plant height but has also less shoots (by 16%) than the Hungarian one. At the same time it was similar to the first year behaviour and the standard deviation was even higher in the Korean population. In the two-years-old population of Korean origin was developed more branches on the shoots as bushy, however compared to the Hungarian population the difference was not signifiant an CV value was high in the Hungarian population. The number of umbels was different compared with one-year-old population. The Hungarian plants had significantly more umbels than the Korean ones (55.1 and 49.5 pcs respectively). However, these values were higher in both taxa than mentioned by Omidbaigi (1993), who registered only 39 umbels/plant in the two-year-old stand in the Hungarian cultivar. The umbel size in the first year and in the second year of vegetation cycle was also considerable different. The Hungarian taxon

Table 1. Characteristics of morphological features in one-year-old of different fennel origins.

	Plant height (㎝)						No. of shoots/ plant		No. of nodes/ shoot		No. of umbels/ plant		Umbel diameter (㎝)		Root length (㎝)	
	July 29		Aug. 19		Oct. 10											
	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.
Mean	82.3	81.6	117.0	108.0	127.0	143.0	7.7	8.3	10.6	12.0	47.0	43.0	10.3	10.9	31.5	28.0
St. Dev.	8.2	16.6	4.5	88.0	28.5	28.5	0.2	0.2	2.7	0.5	24.5	15.5	0.2	0.2	1.4	15.1
CV (%)	9.9	20.4	3.8	81.4	22.4	19.9	2.2	2.0	25.0	4.1	52.1	36.0	1.6	1.4	4.6	54.0

Table 2. Characteristics of morphological features in two-year-old of different fennel origins.

	Plant height (㎝)						No. of shoots/ plant		No. of nodes/ shoot		No. of umbels/ plant		Umbel diameter (㎝)		Root length (㎝)	
	July 29		Aug. 19		Oct. 10											
	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.
Mean	68.2	8.8	142.9	165.8	164.6	187.8	6.8	8.0	8.6	7.0	49.5	55.1	6.8	10.3	5.5	7.3
St. Dev.	35.9	76.6	55.9	47.2	23.2	49.9	2.9	1.3	1.0	2.3	24.2	23.1	2.9	3.0	0.1	0.2
CV (%)	52.8	89.2	39.1	28.5	14.1	26.6	43.5	15.6	11.4	32.1	49.1	42.2	43.5	29.4	0.9	0.9

exceeded the umbel size and numbers to the Korean one (by 3.62 ㎝ in the average) and the variability in the populations was high (CV = 29~49%). Seed size was also proved to be a discriminative feature between the examined taxa. With small deviations (CV < 2) the Hungarian population produced seeds longer by 38% (7.3 ㎜ and 5.5 ㎜ respectively) The values of the Hungarian population are small compared with the measured 7.7 ㎜ of omidbaigi (1993) and 7.6 ㎜ of Kattaa (1996). Thus, the Korean fennel has a small seed character.

In the three-year-old populations, most morphological characteristics showed no significant difference between the populations of different origins. In the last investigated vegetation year, the plant height of Korean one narrowed to the Hungarian taxon and the characteristic differences were disappeared (Table 3). The more advanced growth in the Korean taxon might originate from the weather conditions. In that year the extremely humid weather was characteristic during the intensive growing period in May to June (Table 4). The influence of the year on the morphological features of fennel also observed by Kattaa (1996). Neither of the taxa was adequately homogeneous concerning the height of the stands (CV = 15~34%). Besides intensive growing, the Korean taxon was also characterised by an increased number of stems (8.9 pcs/plant), although its variance was about Twice that of the Hungarian population. The number of branches/shoot did not change much from the second year and there was no significant difference between the two taxa in this respect. The number of umbels were proved by the only statistically differences in the third year's data. Similarly to th second year, Hungarian cultivar developed significantly more umbels than in the Korean population. Diameter of umels was the same in both populations (10.1~10.9 ㎝), and the variances of these data were low (CV = 4.9~6.1). The seed length was longer in the Hungarian population than in the Korean one in the two successive years. It seems to be a characteristical difference between the two taxa and has a low variability (CV values 1~2%). The Hungarian cultivar exhibited a more robust habit higher growth, more stems, larger umbels, and longer seeds. In the third year, the differences of plant height and quantity of shoots might be the results of over growth of the Korean material presumable due to a high amount of precipitation during the vegetation period. Maximum values of plant height and umbel numbers were reached in the second year in both populations, however, in this period the variance also

Table 3. Characteristics of morphological features in three-year-old of different fennel origins.

	Plant height (㎝)				No. of shoots/ plant		No. of nodes/ shoot		No. of umbels/ shoot		Umbel diameter (㎝)		Seed length (㎝)	
	May 13		June 20											
	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.
Mean	81.9	82.5	188.8	183.8	8.9	6.8	8.2	8.3	49.3	52.4	10.1	10.9	5.5	6.2
St. Dev.	12.0	27.8	60.9	31.9	1.1	0.4	1.4	0.4	17.7	20.6	0.6	0.5	0.1	0.1
CV (%)	14.8	33.7	32.3	17.4	12.5	5.8	17.4	4.7	36.0	39.0	6.1	4.9	1.8	2.0

Table 4. Characteristics of production capacity in the one-year-old of different fennel origins.

Organ	Stem weight				Leaf weight				Root weight			
	Fresh		Dry		Fresh		Dry		Fresh		Dry	
	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.	Kor.	Hun.
Mean	38.9	41.6	11.7	14.1	78.7	128.4	18.5	25.3	31.0	41.0	11.9·	15.8
St. Dev.	21.2	37.6	10.3	3.5	38.5	51.2	13.3	10.4	6.7	6.7	1.9	1.9
CV (%)	54.5	90.4	87.7	24.3	48.9	39.8	71.9	41.1	21.6	16.4	15.9	12.1

increased in most of the characteristics. No significant differences were found in the root length and in the number of branches/shoot could in the investigation years. In the studied morphological characteristics, we not find either of the populations being more homogeneous than the other one. Homogeneity in the populations was dependent more on th vegetation year, age of the stands and on the characteristics measured, but less on the origins. Biomass of the two populations proved to be different in the two populations (Table 4). Only the stem produced statistically similar values in the two populations. The leaf mass in almost double in the Hungarian to the Korean one. In case of the roots, the Hungarian population produced root-mass 10g higher than that of the Korean one. In the investigations of Omidbaigi (1993) the mass of the underground parts in one-year-old stand was 26g/plant, while the mass of each organ was 19% lower than in the Hungarian stand, presumable due to less growing to surface. Drying ratio was 2.95~3.32 : 1 in the stems, 4.3~5.1 : 1 in the leaves and 2.5~2.8 : 1 for the roots. In this respect, the behaviour of the two taxa was similar and individual differences proved to be large in both taxa. Standard deviations were the highest in the stem masses in both taxa (CV up to 90%), while the lowest was showed in the root masses (CV below 22%). The mass of thousand seed was significantly different between the two intra-specific taxa at the main growing season (Table 5). The mass productivity of Hungarian taxon exceeds in the 2_{nd} year population an the values coincide in the 3_{rd} year population with Kattaa (1996). The Korean population has an average seed mass similar to the result of Kattaa (1996), who measured it was 3.0~6.1 g in a collection of different origins. Karlsen (1969) reported that seed mass ranges from 5.9~7.1 g in different breeding strains. Similarly, the seed length of Hungarian population (Table 3) exceeded to Korean one in seed mass as well, with 1.64 g and 1.03 g in the two-year-old population, respectively (Table 5). However, the values of the Korean taxon was more stable than the Hungarian cultivar considering lower standard deviations in the two growing seasons.

Table 5. One thousand seed mass of the different populations of fennel.

Population	Two-year-old		Three-year-old	
	Korean	Hungarian	Korean	Hungarian
Mean	4.72	6.36	4.64	5.67
St. Dev.	0.07	0.42	0.01	0.06
CV (%)	1.67	2.01	0.30	1.08

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