

The effect of planting date on growth, seed stalk development and yield of sweet fennel

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Abstract. To study the growth and development of sweet fennel ('ZEFA-Fino' and 'ZEFA-Tardo') seedlings were raised under greenhouse conditions (night temperature 16—18°C) and planted out at 3—4 true leaf stage on May 21st, June 10th, July 7th and July 27th. The effects of covering mulch and short day treatment of seedlings were studied also. First harvests were performed when field measurements showed that the greatest width of 'ZEFA-Fino' bulbs were on average 60 mm. Three harvests were then performed at one week intervals. Plant and bulb weights, bulb greatest width and thickness and, the heights of plant, bulb and stem inside the bulb was measured. The number of bolters were recorded.

The bulb width of 'ZEFA-Fino' reached 60 mm in 1.5—2 months after planting out depending on planting date. Plant and bulb weights, bulb width and thickness, stem height inside the bulb and the bulb height in the earliest plantings increased as the growth period lengthened. The bulb width of 'ZEFA-Fino' was in higher correlation with bulb weight than bulb thickness or height. The ratio between the height of stem inside the bulb and bulb height increased fastest in the lot planted under cover in May and in the lot planted out in June; at the fourth harvest the relationship was 0.8. The largest number of bolters (8 %) was found in the latter lot. The yield estimate for 'ZEFA-Fino' at the third and fourth harvest was 170—360 kg/are depending on planting date and length of the growing season.

All lots of 'ZEFA-Tardo' except that planted in July bolted quickly after the bulb width had grown to 60—70 mm. The yield quality of 'ZEFA-Tardo' was low because of elongated bulbs and great variation in bulb height. Short day treatment (dark period 16 h) of the seedlings retarded but did not inhibit bolting of 'ZEFA-Tardo'.

Index words: sweet fennel, planting date, growth, seedstalk development

Introduction

Sweet fennel (*Foeniculum vulgare* L. var. *azoricum*), an old vegetable in Mediterranean countries (MANSFELD 1986), is cultivated for late season and winter crop especially in Ita-

ly, but also in other South European and some North African countries (BUISHAND & JONGE 1984, VOGEL 1986). During the last few years an interest in growing sweet fennel has arisen

in many Middle and North European countries where efforts have been made to find new varieties for outdoor vegetable production. Several sweet fennel cultivars have been in field tests also in Southern Finland, where the outdoor season lasts from May to September/October, the results, however, were not encouraging enough (SUHONEN 1970) to begin commercial production, but the Swiss cultivar Wädenswil was accepted by home gardeners.

In growing sweet fennel during spring and summer the main problem has been the quick development of seed stalk. As a consequence of this process the "bulb" (the tight bundle of swollen petiole bases) loses its tightness, crispness and commercial value too. Breeding of sweet fennel to diminish the sensitivity to bolting has been done especially in Switzerland, and a year around cultivar ZEFA-Fino was introduced in 1977 (KELLER et al. 1977). According to field tests in Switzerland (KELLER et al. 1977), in FRG (ANDRESEN & FRENZ 1981), in Denmark (HENRIKSEN 1982), in Norway (RYGG & ROED 1986), in GDR (VOGEL 1987) and in Finland (ANON. 1985) 'ZEFA-Fino' yields proper bulbs during spring and summer, but even then there can be many bolters (VOGEL 1987) resulting in heavy loss of commercial sales.

To avoid the bolting losses during the cultivation of sweet fennel, exact information of seed stalk development would be useful, but the information in literature on this subject is limited. Thus experiments were designed to

study the growth pattern, seed stalk development and yield of sweet fennel in early, middle and late season. In early season the effects of a covering mulch and a short day treatment of seedlings were also examined. The experiments were carried out on the test field at our Department in 1987.

Materials and methods

The cultivars in a series of five experiments were ZEFA-Fino and/or ZEFA-Tardo, a late season cultivar (Table 1). Growing recommendations given by KELLER et al. (1977) and by BUIHAND and JONGE (1984) were adapted as follows. The young plants were raised in a greenhouse with night temperature between 16–18°C. Seeds were sown in seedbeds on April 10th, May 5th, June 6th and June 26th. The seedlings at cotyledon stage were pricked into peat pots (FP 622) which were filled with fertilized peat. In experiment B two weeks short day treatment (dark period 16 h from 4 p.m. to 8 a.m.) after 6 days from pricking was given. The control plants were grown under natural long day.

Sweet fennels were planted out when they had 3–4 true leaves. Before planting (Table 1) plants were hardened outdoors for 3–4 days. The planting density was 45 cm × 20 cm. The soil of experimental plots was humous coarse silt with pH 6.8. As basic fertilization of 10 kg/100 m² a compound fertilizer (N 7 %, P 5 %, K 15 %) was given just before planting. Additional nitrogen fertilization with cal-

Table 1. Cultivars, sowing and planting dates, length of plant raising period and growing time on field until first harvest in experiments A, B, C1, C2 and C3.

Experiment	Cultivars	Sowing date	Plant raising (days)	Planting date	Growing time until first harvest (days)
A	ZEFA-Fino	Apr 10	41	May 21	44
B	ZEFA-Tardo	»	41	»	44
C1	ZEFA-Fino and ZEFA-Tardo	May 5	35	Jun 10	43
C2	»	Jun 6	31	Jul 7	45
C3	»	Jun 26	31	Jul 27	56

cium nitrate (2 kg/100 m²) was performed when the petiole bases began to swell. During dry periods the experimental plots were irrigated. Weeds were controlled mechanically. During the growth period the plants were healthy and no treatments with posticides or fungicides were needed.

In experiment A Agryl P-17 sheet was used to study the effects of a covering mulch early in the season. The plants were covered just after planting out and sheet was taken off at the first harvest. The control plants remained uncovered.

First harvest (Table 1) was performed, when the test measurements from the field showed that the greatest width of 'ZEFA-Fino' bulbs were on average 60 mm. The following three harvests were undertaken at one week intervals. At harvest the stem of sweet fennel was cut just beneath the bulb. The height and weight of rosettes were measured and the number of leaves were counted. The plants were then trimmed: sideshoots and loose outer leaves were removed, and the petioles of opened leaves were cut 5 cm over the swollen leaf base, only the innermost leaves which were shorter than 7 cm were left uncut. Trimmed bulbs were weighed individually and the greatest bulb width, height and thickness were recorded. The bulb was then split and the height of the stem inside the bulb was measured. If the seed stalk had already grown out of bulb, the plant was classified as a bolter. In estimating salable yield healthy proper bulbs weighing 100—450 g were included.

All experiments were arranged according to split plot design in quadruplicates. The averages presented in Tables 2—6 are means of 24 individual specimens, if no bolters were found. If bolting percentage was 50 % or more, no averages were calculated.

Results

Covering mulch on the vegetation from end of May to beginning of July increased the

growth of 'ZEFA-Fino' (Table 2). When the average bulb width in covering treatment was 60 mm, the width of control bulbs was only 49 mm. Also the bulb thickness and height were greater in the covering treatment. The average plant and bulb weights at first and second harvests in the covering treatment were 53—56 % greater than the weights of control plants, but the relationship between bulb and plant weights were the same. The cover also accelerated the growth of stem inside the bulb, as well as the stem growth in relation to bulb height, however, only 0.5 % of plants bolted. In the control there were no bolters. The cover especially increased the salable yield of first and second harvests.

'ZEFA-Tardo' plants grown under short day regime were less green after treatment and shorter (24 cm) at the end of plant raising period than the control plants (30 cm), but both had 4 opened true leaves on average. At the first harvest the short day treated plants were higher (47 cm) and heavier (104 g), and they had less true leaves (8.1) than the control plants (42 cm, 94 g, 9.9 true leaves). The treatment retarded the number of bolters and the growth of stem inside the bulb (Table 3), but it was not effective enough to ensure a proper yield. When the average bulb weight of the short day treated plants was 100 g, there were already 17 % bolters in the stand and a week later the bolting percentage was 70 %.

The bulb width of 'ZEFA-Fino' planted on June 10th and on July 7th reached 60 mm after 1.5 months growth in the field, but the last planting lot needed about 10 days more to reach the same stage (Table 4). The growth of bulb width of 'ZEFA-Tardo' was slightly slower (Table 5).

The bolting percentage of 'ZEFA-Tardo' was very high in lots planted out on June 10th and July 7th (Table 5), and even in the last group there were nearly 50 % bolters at the time of the fourth harvest. Bolters in 'ZEFA-Fino' were found only at the fourth harvest in the lots planted out on June 10th (8 %) and on July 7th (4 %), where the effective tem-

Table 2. The effect of covering mulch and harvesting time on the growth of 'ZEFA-Fino' planted May 21st (experiment A). First harvest 44 days (July 34rd) after planting out, subsequent harvests at one week intervals.

	Treatment ^x	Harvest				Mean ^y
		1	2	3	4	
Bulb width mm	M	60	80	82	102	81**
	C	49	64	79	84	69
Number of true leaves	M	8.1	9.0	9.3	10.8	9.3 n.s.
	C	7.3	8.0	9.3	10.1	8.7
Plant height cm	M	61	65	64	61	63*
	C	48	56	59	54	54
Plant weight g (A)	M	176	313	355	504	337*
	C	113	205	307	368	248
Bulb weight g (B)	M	84	153	185	276	175**
	C	54	98	159	196	127
Relation B/A	M	0.48	0.49	0.52	0.55	0.51
	C	0.48	0.48	0.52	0.53	0.50
Bulb thickness mm	M	31	43	45	51	43**
	C	27	35	44	47	38
Bulb height mm (C)	M	82	93	100	120	99**
	C	73	84	92	105	89
Stem height inside bulb mm (D)	M	35	53	62	99	62*
	C	31	43	55	78	52
Relation D/C	M	0.44	0.57	0.63	0.81	0.61
	C	0.43	0.51	0.60	0.74	0.57
Salable yield kg/100 m ²	M	32	165	199	280	169**
	C	0	69	166	216	113

^x M = mulch, C = control

^y and significance of differences between means of M and C, Tukey's test.

Table 3. Effect of short day treatment during plant raising and of harvesting time on bolting and on properties of non-bolted bulbs of 'ZEFA-Tardo' planted out May 21st (experiment B). First harvest 44 days (July 3rd) after planting out, subsequent harvests at one week intervals.

Treatment	Harvest	Non-bolted bulbs					
		Bolting %	Width mm	Weight g	Height mm (A)	Stem height mm (B)	Relation B/A
Natural long day	1	4	45	45	76	47	0.61
	2	46	55	70	91	64	0.71
	3	78	—	—	—	—	—
	4	100	—	—	—	—	—
Short day	1	0	45	50	78	33	0.42
	2	0	58	77	89	52	0.58
	3	17	63	107	102	73	0.71
	4	70	—	—	—	—	—

perature sums were 595°C and 546°C respectively (Figure 1).

In the last planting, 'ZEFA-Fino' plants had less true leaves than in the earlier lots, but they were above average in height (Table 4).

The width and the stem height inside the bulb, and also the thickness of 'ZEFA-Fino' bulbs increased with a longer growing period, but the increase in bulb height was significant only for the lot planted out in June (Table 4). The

Table 4. The effect of planting date and harvesting time on number of true leaves, plant height and on properties of bulbs of 'ZEFA-Fino'. First harvest 43 days (planted June 10th, experiment C1), 45 days (planted July 7th, experiment C2) and 56 days (planted July 27th, experiment C3) after planting out, subsequent harvests at one week intervals.

	Harvest	Planting date		
		June 10th ^x	July 7th ^x	July 27th ^x
Bulb width mm	1	62a	71a	69a
	2	75b	80ab	75ab
	3	93c	87c	79b
	4	98c	96cd	77b
Number of true leaves	1	8.1a	8.4a	7.7a
	2	8.9b	8.6a	7.5a
	3	11.0c	9.0a	7.3a
	4	11.4c	9.1a	7.7a
Plant height cm	1	57a	68a	70a
	2	64a	69a	72a
	3	65a	69a	71a
	4	64a	68a	70a
Bulb thickness mm	1	36a	42a	42a
	2	41a	52b	44a
	3	52b	55b	45a
	4	55b	59b	48a
Bulb height mm (A)	1	84a	104a	95a
	2	95ab	100a	102a
	3	107bc	107a	107a
	4	126c	103a	101a
Stem height inside bulb mm (B)	1	36a	42a	43a
	2	53b	52b	47b
	3	73c	64c	46b
	4	98d	79d	52c
Relation B/A	1	0.42	0.40	0.45
	2	0.55	0.52	0.46
	3	0.68	0.59	0.42
	4	0.77	0.76	0.51

^x Values followed by same letter are not significantly different at $P = 0.05$ by Tukey's test.

increases in average plant and bulb weights between harvests were notable especially in the lot planted out on June 10th (Figure 1). The relationship between bulb weight and plant weight varied from 0.47 to 0.62. This ratio was lowest at the time of the first harvests. The highest ratio was obtained for the lot planted on June 10th at the last harvest. The growth of bulbs in the last planting lot was very slow after the first harvest, but there still was significant increase in bulb weight (73 g) between first and fourth harvest. The increase in effective temperature sum between those harvests was only 46°C.

The salable yield of 'ZEFA-Fino' increased

with a lengthening of the growing period, and the greatest salable yields were achieved from stands planted out on June 10th and on July 7th (Figure 1). The yield of 'ZEFA-Tardo' was low because of bolters, and the yield quality was also poor, because of elongated bulbs and great variation in bulb heights especially for the last planting lot (Table 5).

In bulbs of 'ZEFA-Fino' there were significant correlations between bulb weight vs bulb greatest width, greatest thickness and height in all experiments (Table 6). The best correlation coefficients were between weight vs width. Using the average values of bulb width and bulb weight presented in Tables 2 and 4

Table 5. The effect of planting date and harvesting time on bolting and on properties of non-bolted bulbs of 'ZEFA-Tardo'. First harvests 43 days (planted June 10th), 45 days (planted July 7th) and 56 days (planted July 27th) after planting out, subsequent harvests at one week intervals.

	Harvest	Planting date				
		June 10th	July 7th	July 27th ^a		
				mean	variation	
Bolting %	1	21	29	0		
	2	46	42	4		
	3	92	54	17		
	4	92	67	44		
Bulb width mm	1	59	66	63a		
	2	(67)	(76)	74b		
	3	—	—	73b		
	4	—	—	(72)		
Bulb weight g	1	78	127	116a		
	2	(128)	(197)	161b		
	3	—	—	174b		
	4	—	—	(181)		
Bulb height ^y mm (A)	1	101	119	118a	95—180	
	2	(138)	(151)	130a	90—190	
	3	—	—	131a	95—210	
	4	—	—	(148)		
Stem height ^y inside bulb mm (B)	1	74	72	71a	38—115	
	2	(115)	(113)	83a	40—180	
	3	—	—	88a	55—185	
	4	—	—	(113)		
Relation B/A	1	0.73	0.60	0.60		
	2	(0.83)	(0.74)	0.71		
	3	—	—	0.67		
	4	—	—	(0.76)		

^x Values followed by same letter are not significantly different at $P = 0.05$ by Tukey's test.

^y Great variation between individuals specially in the last planting lot, limits are given in the table.

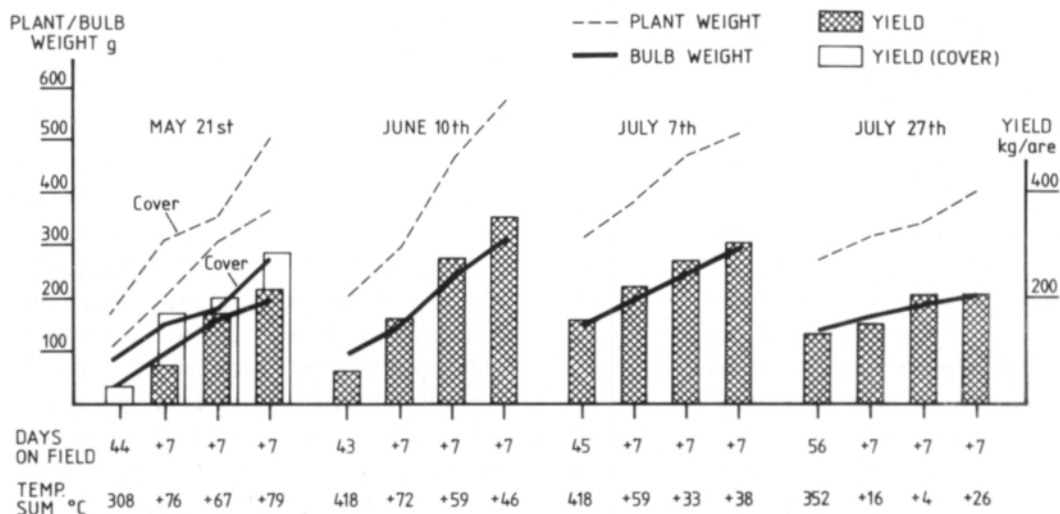


Fig. 1. Plant and bulb weights and estimated salable yield of 'ZEFA-Fino' at harvests 1 to 4 in experiment A (planted May 21st) and in experiments C1, C2 and C3 (planted June 10th, July 7th and July 27th).

Temp. sum = the sum of effective day degrees over 5°C

Table 6. Correlations between bulb weight and bulb width, thickness and height of 'ZEFA-Fino' in experiments A, C1, C2 and C3.

Experiment	Weight vs		
	width	thickness	height
A (cover)	0.94***	0.84***	0.62***
A (control)	0.95***	0.91***	0.64***
C 1	0.91***	0.85***	0.65***
C 2	0.93***	0.81***	0.24*
C 3	0.87***	0.81***	0.33**

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

and in Figure 1, it can be estimated that the bulb size of 100 g was reached when the bulb width was about 64 mm and 200 g when bulb width was about 82 mm.

Discussion

The test cultivars behaved themselves very differently under the prevailing circumstances. 'ZEFA-Tardo' proved to be a quick bolter in spring and in summer as was to be expected, but there was also plenty of bolters in autumn, when it should have yielded proper bulbs. Our results with 'ZEFA-Tardo' are in agreement with the Danish results (HENRIKSEN 1982), but differ from the Dutch results, which showed no bolters in late season cultivation (BUISHAND & JONGE 1984). Short day treatment during seedling phase retarded, but did not inhibit the development of seed stalk of 'ZEFA-Tardo', which agrees with a similar experiment in Denmark (HENRIKSEN 1982). The non-bolted individuals of 'ZEFA-Tardo' gave small bulbs weighing under 200 g, which had relatively long stem inside the bulb.

In contrast to 'ZEFA-Tardo' bolters were only found with 'ZEFA-Fino' when the harvest was 2 months after planting out. In sowing and planting time experiments carried out in Switzerland, the bolting of 'ZEFA-Fino' after about 2 months growing time under field conditions was under 1 %, except in one lot planted out in beginning of July (KELLER et al. 1977). In the Danish experiments there were 1—15 % bolters after two months growing time under field conditions, and after

70 days the percentage of bolters was 37 % in a lot planted out at the end of June (HENRIKSEN 1982). In field tests made in GDR the number of bolters in 'ZEFA-Fino' after about two months growing time was usually high, often over 20 %. It was stated that the speed of bolting depends on weather, and in stands planted out during June or during the two first weeks of July a high percentage of bolting can be expected (VOGEL 1987). In our tests with 'ZEFA-Fino' the tendency was the same; during warmest periods of weather, and under cover the growth of stem inside the bulb was fastest, and some individuals bolted.

The field measurements of bulb width of 'ZEFA-Fino' to forecast the average bulb width in yield gave good correlations in experiments A and C1, but not as good in experiments C2 and C3, where the first harvests were delayed. Obviously there were too long intervals between field measurements. According to our results, the bulb width of 'ZEFA-Fino' is highly correlated to bulb weight, and it is better forecaster for yield than bulb height or thickness. In foretelling the development of seed stalk the measurement of stem length inside the bulb seems to be a good parameter. Our observations indicate, that the relation 0.7 between stem height inside the bulb and bulb height will predict that in warm weather 'ZEFA-Tardo' is likely to bolt. In 'ZEFA-Fino' the same stem/bulb height relation did not give a high number of bolters under the test conditions. A warmer period at this stage could alter the behavior of this cultivar, thus further tests are required.

In our experiments the number of individuals was insufficient for giving an exact prognosis of salable yields. The estimates, however, indicate, that a yield level of 200—300 kg/are for 'ZEFA-Fino' can be reached in 2—2.5 months growing time under field conditions, if young plants are raised beforehand in a hot house and the weight of 100 g per bulb is approved as the lower limit. The leaf yield will be nearly the same as the bulb yield, or slightly smaller with the swelling of bulbs.

According to our observations 'ZEFA-Fino' benefits from a covering sheet early in the season. If 200 kg/are is the target for yield, the covered stand was about a week earlier than the uncovered one. In tests of ANDRESEN and FRENZ (1981) the growing time

of 'ZEFA-Fino' was reduced by nine days, when a perforated plastic cover was kept on a stand planted out in April for five weeks. If the cover is kept on sweet fennel for too long a time, then the bulb weight can be reduced (BUISHAND & JONGE 1984).

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SELOSTUS

Istutustajan vaikutus salaattifenkolin kasvuun ja kehittymiseen

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Kasvihuoneessa esikasvatetun ja kolmi-nelilehtiasteella avomaalle istutetun salaattifenkolin ('ZEFA-Fino' ja 'ZEFA-Tardo') kasvuja ja kehittymistä tutkittiin v. 1987 viiden kokeen koesarjassa. Ensimmäiset erät istutettiin 21.5. ja viimeinen 27.7. Aikaisten erien viljelyssä selvitettiin myös harsokatteen ja taimien lyhytpäiväkasittely (pimeäjakso 16 h) merkitystä.

Kokeissa sato korjattiin ensimmäisen kerran, kun 'ZEFA-Finon' lehtikantakimpun, "mukulan", suurin leveys oli kenttämittausten mukaan 60 mm. Seuraavat 3 korjuuta tapahtuivat viikon välein. Kasvin korkeus ja paino, mukulan paino, korkeus, suurin leveys ja paksuus, mukulan sisässä olevan varren pituus sekä kukkavarren esiinkasvu määritettiin yksilömittauksin.

'ZEFA-Finon' mukulat saavuttivat 60 mm:n leveyden 1,5—2 kuukaudessa istutuksesta lukien. Kasvuajan piteessä yksilöpaino ja mukulan paino, leveys, paksuus sekä korkeus kasvoivat, ja mukulan sisässä oleva varsi piteni. 'ZEFA-Finon' mukuloiden suurimman leveyden ja

painon välinen korrelaatiokerroin oli 0,87—0,95 kokeesta riippuen. Suurimman leveyden ollessa n. 64 mm mukulat painoivat keskimäärin 100 g, ja keskimäärin 200 g, kun suurin leveys oli n. 82 mm. Toukokuun loppupuolella istutetun 'ZEFA-Finon' sato aikaistui noin viikon harsokatteen ansiosta.

Molemmissa lajikkeissa mukulan sisässä olevan varren pituuden suhde mukulan korkeuteen suureni kasvuajan piteessä. Kesäkuun 10. päivänä istutetulla 'ZEFA-Finolla' tämä suhde kasvoi neljänteen korjuukertaan mennessä 0,8:aan, ja tällöin esiintyi eniten (8 %) yksilöitä, joiden kukkavarsi oli kasvamassa tai kasvanut esiin mukulasta. Muutoin tällä lajikkeella kukkavarren esiinkasvu oli vähän. 'ZEFA-Tardolla' kukkavarren kasvu oli yleensä niin nopeaa, ettei kauppakelpoista satoa juuri saatu. Heinäkuun lopussa istutettu erä kehitti kukkavarsia muita hitaammin, mutta siinäkin sato oli heikkolaatuista. Lyhytpäiväkasittely taimivaiheessa hidasti, mutta ei estänyt 'ZEFA-Tardon' kukkavarren kasvuja.