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EFFECT OF THERMAL CONDITIONS ON THE INITIATION OF BROCCOLI CURD

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ABSTRACT

Histological and morphological analysis of growth apexes of broccoli (Brassica oleracea var italica, cv. 'Fiesta') was carried out to determine the time of its transition from a vegetative phase to a generative one, and particularly the time of initiation of inflorescence morphogenesis. Four developmental phases of the apex were distinguished and characterised: vegetative, evocation, early generative (initiation of inflorescence morphogenesis) and late generative. The changes taking place in apical and subapical meristem, as well as the configuration and size of the apex, its width and the sequences of appearance of generative structures, i.e. initials of first order floral stalks, were determined.

To indicate numerical relationships of apex occurrence at subsequent developmental phases, diagrams were made presenting the frequencies in relation to four cultivation terms.

It was found that at different terms of planting out, initiation of inflorescence morphogenesis took place at various grows stages of the plant.

The period from planting out to the early generative phase for each cultivation term was characterised by different sum of heat expressed in day-degrees (temperature range 10-22°C). During 5-6 days before initiation of inflorescence morfogenesis in all cultivation terms the range of temperature was similar.

Key words: broccoli, curd initiation, temperature

INTRODUCTION

Generative differentiation of the broccoli apex was a subject of numerous works. Gauss and Taylor [3] used morphological and histological criteria in the characteristics of the apex in transition from a vegetative phase into a generative one. They presented dynamics of changes and relationships of configuration, meristem size and sequence of appearance of vegetative and generative structures in the form of leaf primordia, and first as well as second order floral stalks. The importance of environmental factors affecting these processes is presented in the works by a number of writers [1, 2, 4, 7, 8]. According to Grevsen and Olesen [6] the minimal temperature for broccoli curd initiation was 9.9°C, the optimal one 16.1°C and the maximal 22.3°C. On the basis of three years of research the authors found different lengths of the period from transplant to initiation in various cultivars and at various cultivation terms in a given year. At the moment of initiation the plants were at different stages of development [5].

The purpose of this work was to determine the moment of initiation of inflorescence morphogenesis against the temperature and development of the vegetative organs of the broccoli cv. 'Fiesta'.

MATERIALS AND METHODS

The experiment was carried out in the Experimental Station of the Department of Vegetable Crops "Marcelin" in 1999. It was set in the random block design in four replications. Transplants of broccoli cv. 'Fiesta' at the phase of 4.5-5 leaves were planted in the field in four dates: 8 April, 6 May, 10 June and 9 July. On each 37.5 m^2 plot 150 plants were placed at the distance 0.5×0.5 m. Air temperature was taken every hour directly on the experimental field with Kestrel type recorder connected to a computer. For the whole period from planting out to early generative phase, a mean daily air temperature was calculated from the hourly measurements as well as a daily sum of heat units within the range of 10-22°C.

From the first week after planting to the moment when a curd of about 1 mm diameter was observed 6-8 apexes were collected, at first at 3-4 day long intervals, and then every day. The apexes were fixed in FAA solution (70% ethyl alcohol, concentrated acetic acid, formalin 90:5:5), dehydrated and passed through ethanol and butyl alcohol. After that they were embedded in paraplast dissected longitudinally on the 12 µm slides stained with safranin and fast green and embedded in Entellan medium. Only the pieces from the middle part of the apex were analysed. To determine developmental phases, histological and morphological parameters of apical meristem were taken into account and also the micrometric measurements of its width between the bases of the two youngest primordia leaves or floral initials were made. These measurements included a sample of 15 apexes for the vegetative, initial and late generative phases as well as a sample of 30 apexes for the early generative phase. The arithmetic mean and coefficient of variability were calculated and the extremal values of the width of apical meristems were given.

The numerical proportion of the apexes in a given developmental phase is presented in diagrams taking into account their frequencies in each sample from a given day of cultivation (figs 1-4).

Fig. 1. Developmental phases of growth apexes of broccoli cv. 'Fiesta' planted out on 8 April, 1999

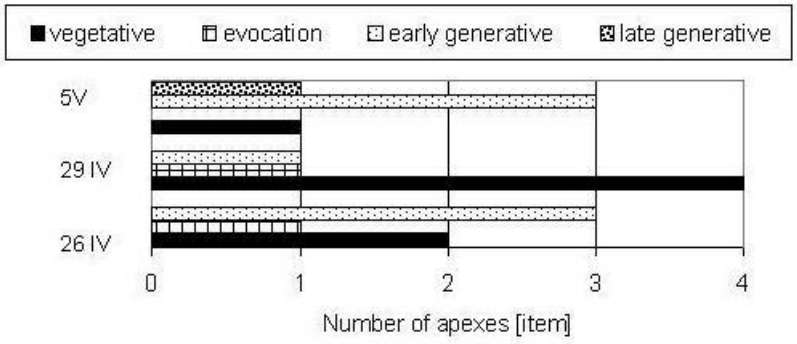


Fig. 2. Developmental phases of growth apexes of broccoli cv. 'Fiesta' planted out on 6 May, 1999

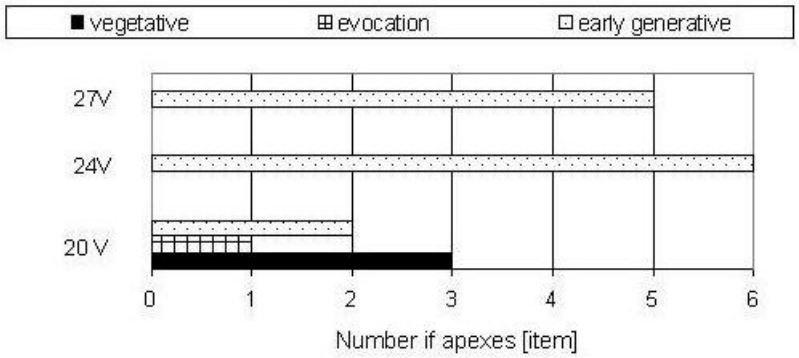


Fig. 3. Developmental phases of growth apexes of broccoli cv. 'Fiesta' planted out on 10 June, 1999

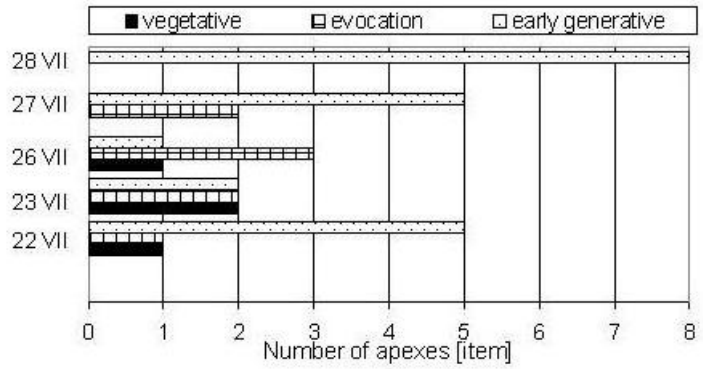
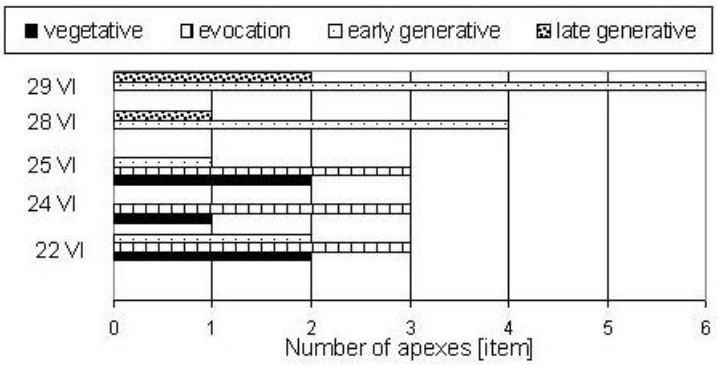


Fig. 4. Developmental phases of growth apexes of broccoli cv. 'Fiesta' planted out on 9 July, 1999



In the plants from which the apexes were taken, the number and area of leaves, stem diameter and dry mass of over-ground plant part were determined.

RESULTS

A) Developmental phases of broccoli terminal bud

Four developmental phases of the broccoli apex were distinguished:

- The apex in vegetative phase (fig. 5) was dome-shaped with leaf primordia rather distant from the top area. Distal zone of the apex was built from initial cells and their derivatives including several layer thick tunic. In proximal zone the peripheric meristem consisting of small basophilic cells and central meristem built of greater, more vacuolised cells, were well distinguished. Proximal zone of the apical meristem transferred directly into histo- and organogenesis region with differentiating procambial bands and leaf primordia. In this phase the apex width was 303 µm (tab. 1) and was much greater than in cv. 'Coastal' 147 µm [3].
- The apex in the initial (evocation) phase (fig. 6) was wider (375 µm) and less domed than in the previous phase, and the cells of distal zone were more basophilic which indicates increased activity of this part of the meristem (in cv. 'Coastal' the apex width was 183 µm).
- The apexes in the early generative phase included the stadium directly preceeding initiation of inflorescence morphogenesis (fig. 7) and initiation of morphogenesis (fig. 8). Due to increased activity of the distal part of meristem and meristematic coat, considerable elongation, broadening and flattening of the apex took place, and in place of leaf primordia, first initials of first order floral stalks appeared. Mean apex width was 476 µm (in cv. 'Costal' from 227 to 259 µm).
- The apex in the late generative phase (fig. 9) showed growth of the cells of parenchymatic core, due to which it elongated and broadened considerably. Its width was 619 µm while that in cv. 'Coastal' only 275 µm [3]. The apical region was considerably elevated over the level of leaf primordia in place of which numerous initials of first order floral stalks and florets were present.

Fig. 5-9. Developmental phases of growth apex of broccoli cv. 'Fiesta' from vegetative to generative

Fig. 5. The apex in the vegetative phase much domed, narrow with developed apical meristem

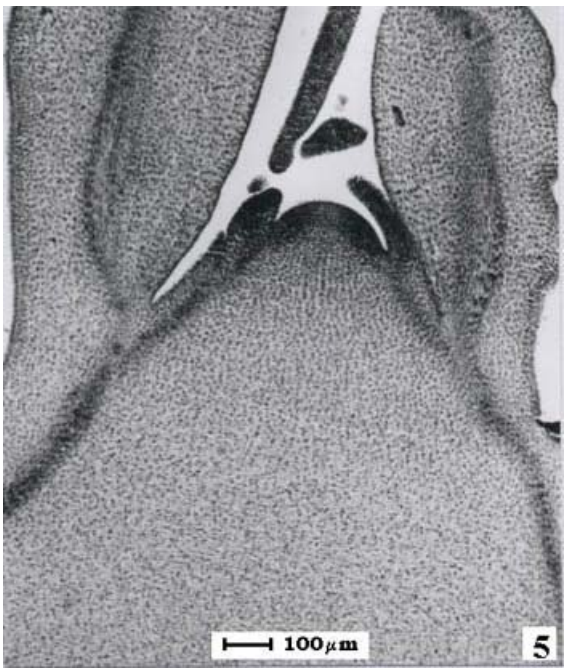
Fig. 6. The apex in the initial stage (evocation); older leaf primordia bend horizontally and constitute a cover of the apex

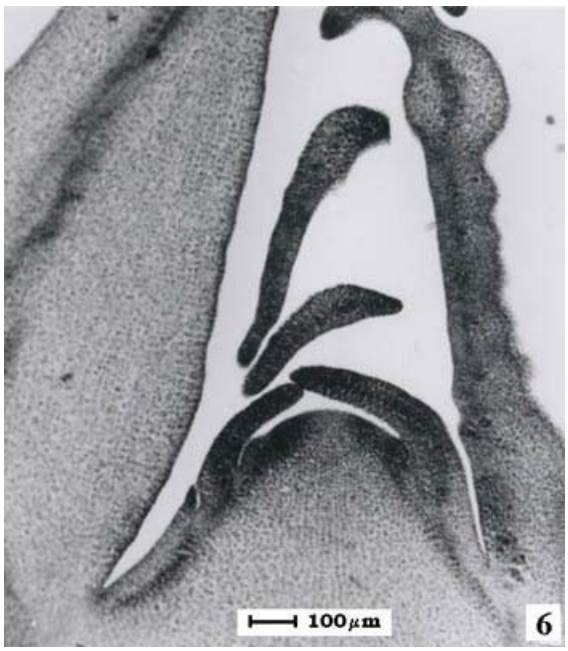
Fig. 7 and 8. The apexes at different stages of the development of the early generative phase

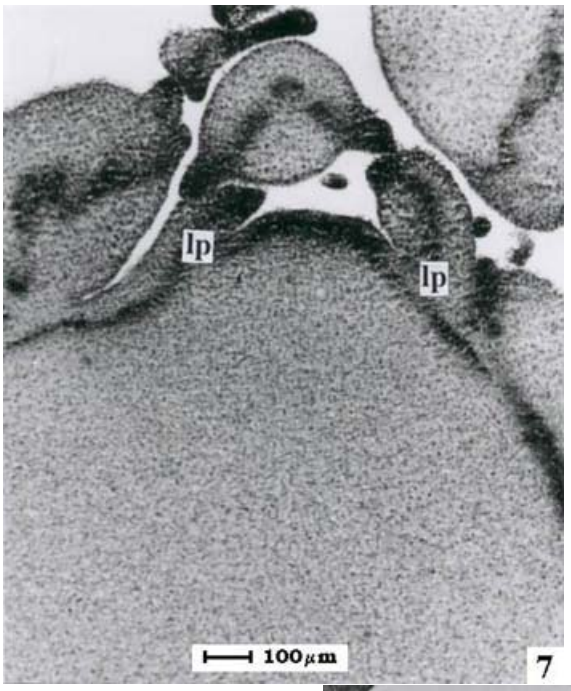
Fig. 7. The apex partially flattened, shortly prior creation of inflorescence initials (l.p. leaf primordia)

Fig. 8. The apex considerably flattened: in place of leaf primordia appear the initials of first order floral stalks (f.p.): strongly bent cover leaves are present

Fig. 9. The apex in the late generative phase strongly elongated and broadened with successively developed initials of first order floral stalks (f.p.) and florets (b)







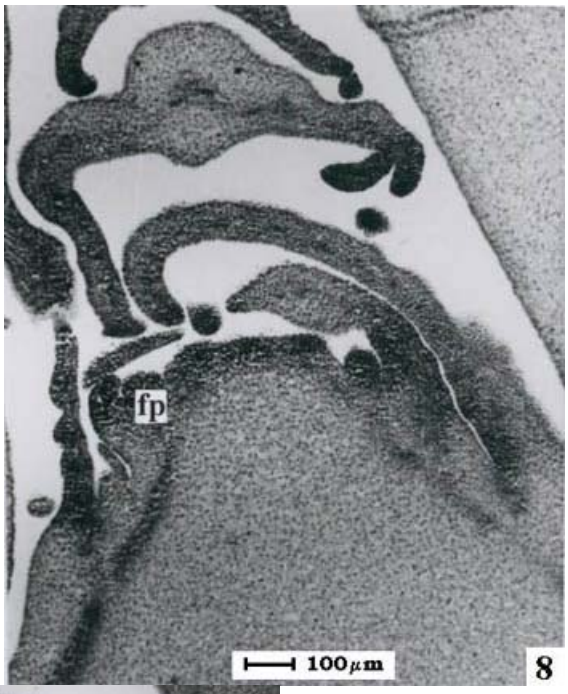


Table 1. Width of growth apex of broccoli cv. 'Fiesta' in four developmental phases

Developmental phase	Apex width (mm)			Coefficient of variability (%)
	Minimal	Mean	Maximal	
Vegetative*	213	303	512	28.2
Initial (evocation)*	241	375	470	17.3
Early generative**	225	476	646	20.1
Late generative*	651	902	1211	17.2

***mean calculated from measurements on 15 apexes**
****mean calculated from measurements of 30 apexes**

B)Interdependence of cultivation terms and vegetative development

The period between planting out and initiation of morphogenesis was constant and amounted to 18 days (fig. 10) while the time between sowing and planting out was differentiated which decided about the difference in the number of days from sowing to initiation of inflorescence morphogenesis.

The date of planting influenced differentiation of dependence between the number and the area of leaves, and dry mass and the term of initiation of inflorescence initiation (tab. 2). From the relationship between the number of leaves and their area ensue that the rapid increase of the area was rather due to increase in the area of the already existing leaves than to the number of new ones.

Particularly interesting seems to be the fact that in each subsequent crop the number, area and dry mass of the leaves increased while the length of the period from planting out to generative morphogenesis initiation remained constant.

Fig. 10. The length of vegetation period of broccoli cv. 'Fiesta' planted out at four dates in 1999

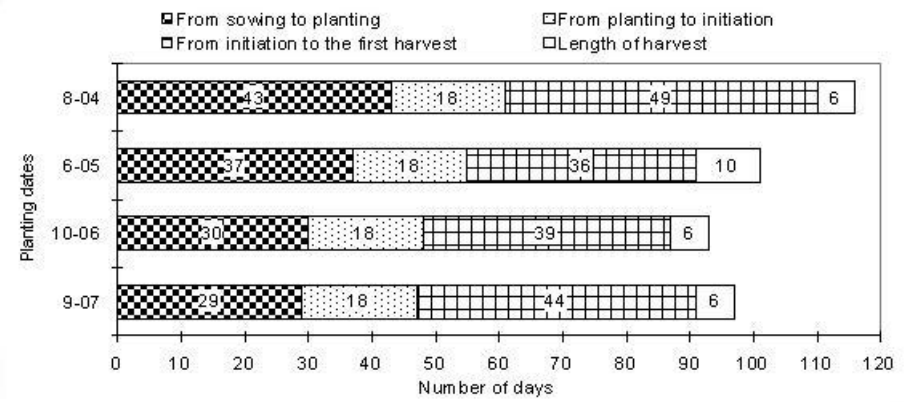


Table 2. Morphological characteristics of broccoli cv. 'Fiesta' plants in the early generative phase depending on the planting date

Planting date	N° of leaves	Stem diameter (mm)	Leaf area (cm^2)	Dry mass of over-ground part (g)
8.04	6.2	5.9	224	2.0
6.05	8.4	5.2	412	6.1
10.06	10.5	6.0	849	7.7
9.07	10.4	7.0	784	7.1

C) Characteristics of thermal conditions

The lowest number of day-degrees calculated for the temperature range from 10 to 22°C was found at planting out on 8 April (32.9) and the highest (89.0) at planting on 11 June (tab. 3). On the remaining two cultivation terms the number of day-degrees ranged from 63.1 to 75.3.

Table 3. The number of days. heat sum and mean daily air temperature in the period from planting out to the early generative phase in broccoli cv. 'Fiesta' grown in four terms

	Planting date			
	8.04	6.05	10.06	9.07
No of days (10-22°C)	8	16	18	18
Heat sum (day-degrees 10-22°C)	32.9	63.1	89.0	75.3
Daily mean*	9.8	14.1	17.3	22.0

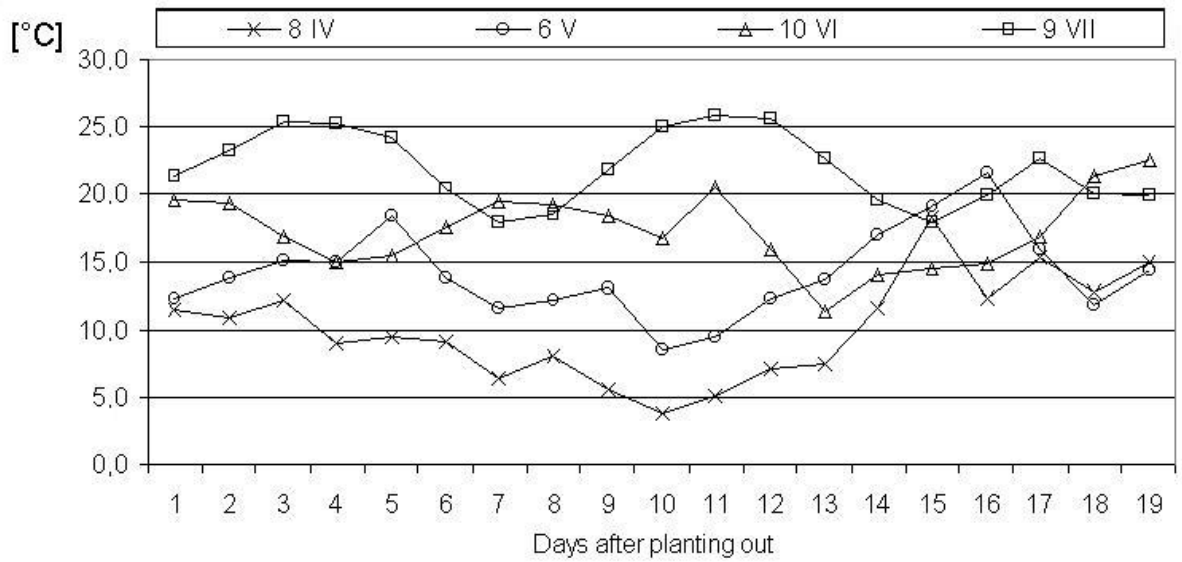
***mean for the whole range of temperatures**

The later planting out date the higher was the mean daily air temperature. At planting out in April the daily mean temperature was over twice lower than at planting out in July.

During the whole period from planting out to the early generative phase the lowest temperatures appeared at planting in April (from 4 to 18°C) and the highest at planting in July (from 18 to 26°C). The course of the mean daily air temperature at planting out in May and June was within the range of 9 to 21°C (fig. 11).

During 5-6 days before entering of the plants into the early generative phase at all cultivation terms the temperature range was similar: from 12 to 23°C.

Fig. 11. The course of the mean daily air temperature during the period from planting out to the early generative phase in broccoli cv. 'Fiesta' grown in four terms



CONCLUSIONS

1. The length of the period from planting out to initiation in all terms was 18 days, however the period from sowing to planting out was differentiated and lasted 43 days (for the plants planted out in April) and 30 and 29 days for the plants planted out in June and July respectively..
2. The later was the time of planting out the greater were the number and area of leaves, diameter of stem and dry mass of over-ground part of the plants in the phase of curd initiation.
3. The terms of cultivation were characterised by a different number of day-degrees for the air temperature range 10-22°C measured for the period from planting out to curd initiation.

REFERENCES

1. Bjorkman T., Pearson K. J., 1997. High temperature arrest of inflorescence development in broccoli (*Brasica oleracea* var. *italica* L.) J. Experimental Botany 49, 101-106.
2. Fontes M. R., Ozbun J. L., Sadik S., 1967. Influence of Temperature on Initiation of Floral Primordia in Green Sprouting Broccoli. J. Amer. Soc. Hort. Sci. 91, 315-320.
3. Gauss J. F., Taylor G. A., 1969a. A Morfological Study on the Time of Reproductive Differentiation of the Apical Meristem of *Brassica oleracea* L. var. *italica*, Plenck, cv. 'Coastal'. J. Amer. Soc. Hort. Sci. 94, 105-108.
4. Gauss J. F., Taylor G. A., 1969b. Environmental Factors Influencing Reproductive Differentiation and the Subsequent Formation of the Inflorescence of *Brassica oleracea* L. var. *italica*, Plenck, cv. 'Coastal'. J. Amer. Soc. Hort. Sci. 94, 275-280.
5. Grevsen. K., 1998. Effects of temperature on head growth of broccoli (*Brassica oleracea* L. var. *italica*): Parameter estimates for a predictive model. J. Hort. Sci. Biotech. 73 (2), 235-244.
6. Grevsen K., Olesen J. E., 1999. Modelling development of broccoli (*Brassica oleracea* L. var. *italica*) from transplantig to head initiation J. Hort. Sci. Biotech. 74 (6) 698-705.
7. Miller C. H., Konsler T. R., Lamont W. J., 1985. Cold Stress Influence on Premature Flowering of Broccoli. HortScience 20(2), 193-195.
8. Miller C. H., 1988. Diurnal Temperature Cycling Influences Flowering and Node Numbers of Broccoli. HortScience 23(5), 873-875.

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