Neth. J. agric. Sci. 24 (1976): 58-66

Flower induction in perpetual kale (Brassica oleracea var. ramosa DC)[1]

H. G. Kronenberg

Department of Horticulture, Agricultural University, Wageningen, the Netherlands

Accepted: 17 October 1975

Index words: Perpetual kale, *Brassica oleracea* var. *ramosa* DC, flower induction

Summary

Perpetual kale, a branching cole cultivar, can be induced to 100 % flowering by at least 9 weeks of temperatures between 2 - 6 °C, 4 °C being the best. Plants grown in a 17 °C greenhouse must be 14 weeks old to be receptive to this cold treatment. Perpetual kale has periods of active and less active growth; at 14 weeks of age growing points are active enough.

Normal cultural practices are aimed at a good crop of leaves, which implies that active growing points will be scarce at the end of the season. As perpetual kale can be grown in warm climates too, this plant, as a rule, will flower infrequently or not at all.

Introduction

Perpetual kale is a primitive, branching cole cultivar which seldom forms flowers (Fig. 1). In normal cultivation young side shoots are used as cuttings and rooted in spring, while harvest of the leaves is in autumn and winter. The plants stand cold winters very well, but can also be grown in warmer climates, where other cole cultivars are not satisfactory (Danart et al., 1963). The plants are suitable for allotment gardens, because they seem to be resistant to clubroot.

Page (1971) reports that he successfully rotated perpetual kale every second year for over 30 years. The Scotttish Plant Breeding Station as well as the Welsh Plant Breeding Station were interested in this kale because of its clubroot resistance, but the Scottish Station failed to bring the plant into flower and in Wales it flowered only once (McNaughton, pers. commun., 1971).

In general, cole crops can be induced to form flower buds by periods of low temperature. For instance, brussels sprout plants initiate flowers when kept at 7 °C for 9 weeks (Verkerk, 1954). In this case flower initiation has a low optimum tempe-

[1] Publication 426, Laboratorium voor Tuinbouwplantenteelt, Landbouwhogeschool, Wageningen, the Netherlands.

Fig. 1. Perpetual kale plants with few or no flowers 4 June 1973 after a winter outdoors.

rature and this is not considered as true vernalization. The fact that perpetual kale rarely flowers under normal cultural conditions means that under these conditions flowering is inhibited by causes inside and/or outside the plant.

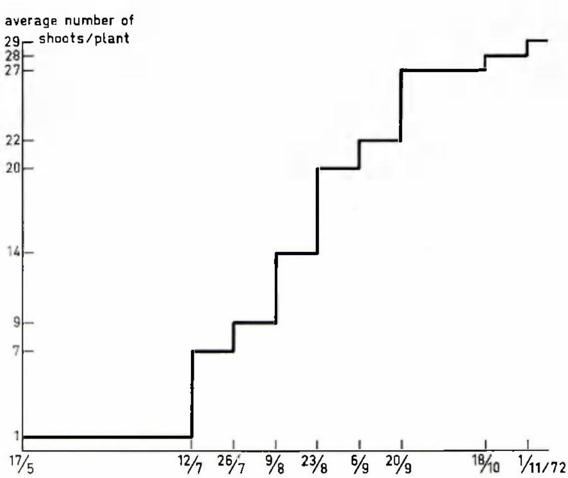

Fig. 2. Average number of shoots on perpetual kale plants grown in the open.

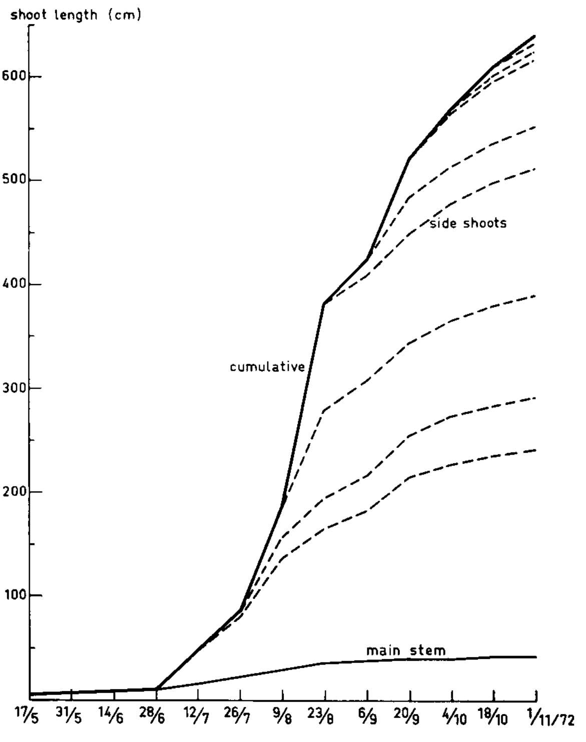

Fig. 3. Length of shoots on perpetual kale plants grown in the open.

Growth in the open

In 1972 a first experiment was done to gather information about the growth of this cole cultivar. On 7 March 6-cm long young side shoots were used as cuttings, which were struck in a 2 sand/1 peat mixture and rooted at 20 °C. The young plants were potted in garden soil, hardened off and 5 were planted outdoors on 17 May. From this date onwards shoots longer than 2 cm were counted and their lengths measured every fortnight. Fig. 2 gives the number of shoots and Fig. 3 the shoot lengths.

A certain rhythmic growth pattern was observed: at first only the main stem grew; then side shoots started developing in flushes: around 28 June a first flush, around 9 August a second and around 6 September a third. Later in the season the plants grew slowly and only a few new shoots were formed.

Growth under controlled conditions

In 1974 perpetual kale plants were grown under controlled conditions. In brussels sprouts an endogenic periodicity has been found with a period of 8 to 16 weeks (Kronenberg, 1974); as perpetual kale is supposed to be related to brussels sprouts (Danart et al., 1963), it seemed worth-while to investigate whether a similar period-

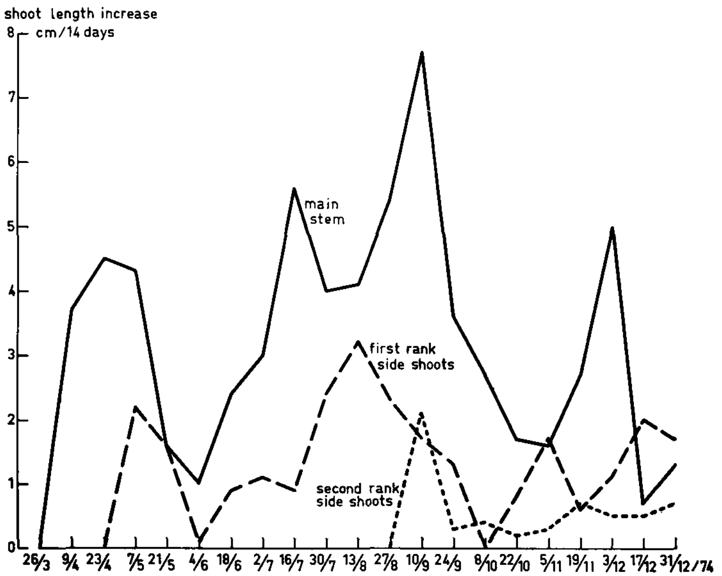

Fig. 4. Shoot length increase (cm per 14 days) in perpetual kale plants grown at 17 °C and 16 hours of fluorescent light.

icity occurred in perpetual kale, the more so because the 1972 experiment had given some indications. Leaf-bud cuttings were struck on 7 February in a 2 sand/1 peat mixture and potted on 21 February in garden soil. On 26 March the plants were potted on in 25-litre buckets and 4 were brought to the 17 °C air-conditioned growing room of the phytotron (described by Doorenbos, 1964) and given 16 hours of fluorescent light. Every fortnight all shoots were measured. The experiment was continued until 31 December, when the plants had become so large and densely branched that exact measurements were not longer possible. Fig. 4 gives the results.

In perpetual kale, too, a rhythmic growth pattern was found. In the main stem this had a period of 12, 8 and 12 weeks; in the side shoots of the first rank 16 and 12 weeks; in the side shoots of the second rank maybe 10 weeks. This means that perpetual kale shows exactly the same periodicity as brussels sprouts.

This rhythmic growth behaviour shows that the meristems of the plants pass through periods of greater and lesser activity. It seemed possible that the plant shows corresponding fluctuations in its sensitivity to certain external stimuli.

Flower induction

In 1973 a first experiment was done to obtain some information about the reaction of perpetual kale to a cold treatment. All plants used had been grown from leaf-bud cuttings which were struck in a 2 sand/1 peat mixture (21 °C). After 3 weeks the young plants were potted in garden soil and grown in a 17 °C greenhouse. All plants

Table 1. Percentage flower induction in perpetual kale; experiment 1973.

Temperature (°C)	Duration of cold treatment (days)					
	40	45	60	80	90	120
3			15		15	0
6		40	5		5	0
9	0			0		

were 8 weeks old at the beginning of the cold treatments. There were 9 series, every series containing 20 plants. Cold treatments, which were given in cold storage rooms with weak fluorescent light, ended all on the same day. The plants were moved again to a 17 °C greenhouse, where flowering started on 4 March 1974. Results of this experiment are given in Table 1.

It was difficult to interpret these results. The young plants had been grown at different periods of the year and were perhaps not of the same physiological age: some had been grown during December-January (those of the 40-day treatment), others (those of the 120-day treatment) during September-October. A temperature of 9 °C seemed too high to induce flowering.

In the next, 1974, experiment younger plants were used, 4, 6 or 8 weeks old. The duration of the cold treatments was 5, 6 or 7 weeks, while temperatures were 4, 6 or 8 °C. Plants were prepared in the same way as described above. For technical reasons all cold treatments had to start on the same day. Therefore cuttings for 8-week old plants were struck on 31 July, for 6-week old plants on 14 August and for 4-week old plants on 28 August. The 8-week series comprised 14 plants, the 6-week series 20 and the 4-week series 17. Realization of flowering was again in a 17 °C greenhouse. Results are given in Table 2.

Table 2. Flower induction in perpetual kale; experiment 1974.

Number of treatment[1]	Percentage of flowering	Number of treatment[1]	Percentage of flowering	Number of treatment[1]	Percentage of flowering
4.5.4.	0	6.5.4.	5	8.5.4.	0
4.5.6.	0	6.5.6.	0	8.5.6.	0
4.5.8.	0	6.5.8.	0	8.5.8.	0
4.6.4.	0	6.6.4.	5	8.6.4.	21.4
4.6.6.	0	6.6.6.	5	8.6.6.	7.1
4.6.8.	0	6.6.8.	0	8.6.8.	0
4.7.4.	11.8	6.7.4.	25	8.7.4.	23.1
4.7.6.	23.5	6.7.6	10	8.7.6.	8.3
4.7.8.	0	6.7.8.	0	8.7.8.	0

[1] First figure: age of plants (weeks); second figure: duration of cold treatment (weeks); third figure: temperature (°C).

Table 3. Flower induction in perpetual kale; experiment 1975.

Number of treatment[1]	Percentage of flowering	Number of treatment[1]	Percentage of flowering	Number of treatment[1]	Percentage of flowering
6.7.2.	10	10.7.2.	0	14.7.2.	20
6.7.4.	30	10.7.4.	0	14.7.4.	70
6.7.6.	20	10.7.6.	60	14.7.6.	70
6.8.2.	0	10.8.2.	10	14.8.2.	40
6.8.4.	30	10.8.4.	50	14.8.4.	90
6.8.6.	70	10.8.6.	50	14.8.6.	70
6.9.2.	10	10.9.2.	10	14.9.2.	70
6.9.4.	30	10.9.4.	80	14.9.4.	100
6.9.6.	40	10.9.6.	50	14.9.6.	100
6.10.2.	20	10.10.2.	60	14.10.2	100
6.10.4.	40	10.10.4	30	14.10.4.	100
6.10.6	40	10.10.6.	50	14.10.6.	90

[1] First figure(s): age of plants (weeks); second figure(s): duration of cold treatment (weeks); third figure: temperature (°C).

From this second experiment one may conclude:
1. At an age of 8 weeks the plants are more responsive than at 4 or 6 weeks.
2. A cold treatment of 7 weeks gives a better response than of 5 or 6 weeks.
3. 4 °C is better than 6 °C; 8 °C was still too high.

It was decided that a third experiment was needed, because in this second experiment only 23.5 % flowering was obtained. Plants used in this last, 1975, experiment were 6, 10 and 14 weeks old. Duration of cold treatments was 7, 8, 9 and 10 weeks, and temperatures were 2, 4 and 6 °C. So, there were 36 series, each of 10 plants. All cuttings were struck on 29 January (in the same way as described earlier) and young plants were brought into the cold storage rooms on 12 March, 9 April or 7 May. Realization of flowering started between 30 April and 16 July in a 17 °C greenhouse. Results are given in Table 3.

In all series younger than 14 weeks flowering could be induced in the main growing point only, but several plants of the 14-week series flowered on more shoots, as is shown in Table 4 and Fig. 5.

The conclusions from this third experiment are:
1. Plants of 14 weeks are old enough to respond to low temperature by initiating flower buds.
2. At 4 °C, a cold treatment of 8 weeks is sufficient; at 2 °C and at 6 °C at least a 10-week cold treatment is required for 100 % flowering.

Discussion

With regard to flowering the perpetual kale plant is very particular. Active growing

Table 4. Flowering in perpetual kale.

Series number[1]	Percentage of flowering	Number of plants with more than 1 stalk	Number of stalks	Average number of stalks
14.7.2.	20	—	—	—
14.7.4.	70	—	—	—
14.7.6.	70	4	12	3
14.8.2.	40	1	3	3
14.8.4.	90	8	23	2.9
14.8.6.	70	5	17	3.4
14.9.2.	70	2	6	3
14.9.4.	100	5	8	1.6
14.9.6.	100	5	6	1.2
14.10.2	100	4	9	2.2
14.10.4.	100	9	34	3.8
14.10.6.	90	9	43	4.8

[1] First figures: age of plants (weeks); second figure(s): duration of cold treatment (weeks); third figure: temperature (°C).

points seem to be needed to perceive a cold stimulus, but the branching growth habit of this plant distributes growing energy so much, so that even at the end of the season there is still only a single growing point active enough. This interaction between age of plants and the formation and number of side shoots was not understood at first, so that the second flower-inducing experiment was done with plants which were too young to have meristems of sufficient activity. In the first, 1972, experiment on growth it was found that plants of about 14 weeks old were most active, while the 1974 experiment on growth under controlled conditions showed that this kale had an internal periodicity. So, in the last experiment on flower induction older plants were used, and the results showed that the meristem activity hypothesis was right and a 100 % flowering was realized.

In this third experiment some plants flowered on more than one shoot. When induction was 100 %, deep or early younger growing points too initiated flower buds. This initiation of younger growing points was not obtained in earlier experiments, and there is no reason to suppose that in this case plants behaved otherwise. A formed flower-inducing substance must be transported from the main growing point to the nearby growing points. While induction is best at 4 °C, transport of this stimulus seemed better at 6 °C, although evidence for this assumption is rather weak (2 cases).

It is possible to understand why under normal cultivation plants flower so infrequently, now a 100 % flowering has been obtained. To profit most of the short growing season cuttings are normally taken early in the year, and at the end of the

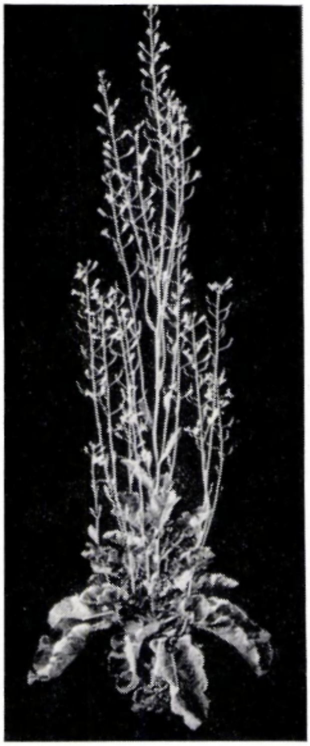

Fig. 5. Flowering perpetual kale plant. 14-week old plant after 10 weeks of 6 °C cold treatment on 8 August 1975.

season big plants with many leaves have developed. In autumn the many growing points are not very active any more; there are too many of them and the growing conditions are far from favourable. After the winter of 1972, which was mild, kale plants flowered in Wageningen, while they never did in Scotland. Temperatures of the growing season in De Bilt (the Netherlands) were 2-3 °C higher than those in Edinburgh (Scotland). There will also be more light, which means that growing points in the Netherlands will be a little more active than in Scotland. This may be one reason of the different flowering behaviour.

Another reason may be that winter temperatures must be low enough over a rather

Table 5. Average monthly air temperatures (°C) in De Bilt (the Netherlands) and in Edinburgh (Scotland).

Month	De Bilt (1931-1960)	Edinburgh (1921-1950)
November	6.2	6.1
December	3.0	4.4
January	1.8	3.9
February	2.3	3.9
March	5.4	5.3

long period. Table 5 gives temperatures in De Bilt and Edinburgh, showing that in both countries over a period of 17-21 weeks temperatures are low enough to induce flowering, while differences seem of no great importance, temperatures at Edinburgh being nearer to 4 °C. The difference in flower induction behaviour therefore more likely has to be attributed to differences in growing conditions than on suitable temperature regimes during the winter.

References

Danart, S., P. Metzner, A. Rieth & H. Sagromsky, 1963. Die Kulturpflanze, Band 11: 108-110. Brno.

Doorenbos, J., 1964. Het fytotron van het Laboratorium voor Tuinbouwplantenteelt der Landbouwhogeschool. *Meded. Dir. Tuinb.* 27: 432-437.

Kronenberg, H. G., 1974. Rhythmic growth phenomena in brussels sprout plants. *Neth. J. agric. Sci.* 22: 101-106.

Page, J., 1971. Perpetual kale. *Amateur Gardening* (8 May) 49.

Verkerk, K., 1954. The influence of low temperature on flower initiation and stem elongation in Brussels sprouts. *Proc. Kon. Akad. Wet. Ser. C* 57: 341-345.