

EFFECT OF VERNALIZATION AND DAYLENGTH  
ON NUMBER AND SHAPE OF LEAVES IN CHICORY  
AND ENDIVE

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(*Publication 189, Laboratorium voor Tuinbouwplantenteelt,  
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(*received January 22nd, 1959*)

INTRODUCTION

Some years ago HARTMAN (1956) found that vernalization has pronounced after-effects on leaf morphology in chicory, *Cichorium intybus* L. In 1956 a small experiment to test these observations not only confirmed Hartman's results but led to the additional observation that vernalized plants formed a smaller number of leaves per unit of time than unvernallized ones. As a consequence there was a steadily increasing difference in size between plants belonging to the two groups.

As it seemed worth while to confirm and extend this incidental observation, an experiment was undertaken in 1957 with both chicory and the related species endive, *Cichorium endivia* L. This was followed in 1958 by an experiment designed to give more data on the effect of daylength on leaf number in these two species.

MATERIAL AND METHODS

The varieties used were chicory "Selectiva" and endive "Fullheart No 5", both from the firm of Nunhem, Haelen (L.), Netherlands. Seed was soaked during 6 hours and presprouted at 26° C during 24 hours. In 1957 the germinating seed was vernalized at 1° C during 0, 2 or 4 weeks. In 1958 endive seed was subjected to 5° C during 0, 2 or 6 weeks and chicory seed was vernalized during 0, 2, 4 or 8 weeks. The treatments were so timed that all groups of one experiment could be sown on the same date. In 1957 all seed was sown on May 22; in 1958, endive seed was sown on June 23 and chicory seed on July 7.

Plants were grown in pots placed on lorries that were in the open from 8 AM to 4 PM and were then rolled into sheds where plants receiving a long-day treatment were subjected to 8 hours of weak light from incandescent lamps followed by 8 hours of darkness, while groups receiving a short-day treatment were in darkness during the whole 16-hour period. In 1957 there were 25 plants per treatment; in 1958 10 plants out of each group were studied.

## RESULTS

## 1. Chicory

In 1957 the number of fully grown leaves was counted every two weeks. To preclude mistakes caused by dying off of the oldest leaves, after each counting a hole was punched in the youngest leaf counted. The results are given in Table I.

TABLE I  
Increase in leaf number of chicory after various vernalization treatments (day-length: 8 hours)

Days after sowing Pretreatment at 1° C	30	54	68	82	96
0 weeks	4.8	10.4	15.8	20.2	24.0
2 weeks	4.3	9.6	15.2	20.3	24.3
4 weeks	4.4	9.3	14.4	18.2	21.9

It is clear that plants vernalized during 4 weeks form a smaller number of leaves than the other groups, but the difference is not large.

In 1958 the differences were more pronounced. Leaf numbers were counted only once, viz. 70 days after sowing. This time not the number of fully grown leaves was established, but the total number of leaves and leaf primordia longer than 3 mm. The data are given in Table II.

TABLE II  
Number of chicory leaves > 3 mm 70 days after sowing following various vernalization treatments

Weeks at 5° C Daylength	0	2	4	8
8 hours	12.5	12.9	10.6	
16 hours	27.5	24.8	15.7	15.1
natural long day	13.4	11.4	8.0 <sup>1)</sup>	9.7 <sup>1)</sup>

<sup>1)</sup> very few plants.

There is a clear effect of vernalization in all groups, but also a striking difference in leaf number between plants in 8 hours of daylight and in 8 hours of daylight + 8 hours of incandescent light. On the other hand, plants grown in natural long day have a much smaller leaf number than those in artificial long day, but this can probably be explained by the fact that the former were subjected to lower night temperatures than those in the sheds.

## 2. Endive

In 1957 an experiment was designed to determine whether the after-effects of low temperature on leaf morphology, found by HARTMAN (1956) in chicory, occur in endive also. Not only was the number of leaves established, but other characteristics of the leaves were observed also. This led to the results given in Table III.

TABLE III

Effect of vernalization on vegetative characters of endive after 3 months in 8-hour days

Length of vernalization Characteristic	0 weeks	2 weeks	4 weeks
Number of leaves	52	51	34
Fresh weight per plant	55.5 g	44.5 g	32.0 g
Leaf length	10.3 cm	10.5 cm	11.9 cm
Leaf width	6.5 cm	6.9 cm	8.2 cm
Leaf thickness	185 $\mu$	170 $\mu$	150 $\mu$

These data show that vernalized endive plants formed a smaller number of leaves than unvernalsized plants and consequently had a lower fresh weight. Moreover leaves of vernalized plants were longer, broader and thinner than those of unvernalsized plants. They were also smoother, more upright and slightly more pilose, although the effect of vernalization on the number of hairs was not nearly as pronounced as in chicory.

These observations were confirmed in 1958. Fresh weight and number of leaves > 3 mm were established only once, viz. 80 days after sowing. The data are given in Table IV.

TABLE IV

Effect of vernalization and daylength on fresh weight and number of leaves &gt; 3 mm of endive

Length of vernalization Characteristic	0 weeks	2 weeks	6 weeks
	Daylength 8 hours		
Leaf number	72.0	64.3	44.5
Fresh weight	70.0 g	85.0 g	65.0 g
	Daylength 16 hours		
Leaf number	33.9	27.5	bolted
Fresh weight	41.8	33.3	

Except for the weight of the unvernalsized group in short day, which is unexpectedly low, the differences in fresh weight reflect those in leaf number. Both vernalization and long day cause an increase in length and width of the leaves, but these differences are small in comparison to the decrease in leaf number. The difference in length between leaves of the same rank on vernalized and unvernalsized rosettes is given in Fig. 1 and 2.

It follows from the data in Table III that leaves from vernalized plants are broader than those from unvernalsized plants, not only in the absolute but also in the relative sense. This was also confirmed in 1958, as shown by Table V.

The ratio of length to width is smaller (i.e., the leaf is relatively broader) in long day than in short day, while in both daylengths vernalization lowers the ratio, i.e. causes broader leaves.

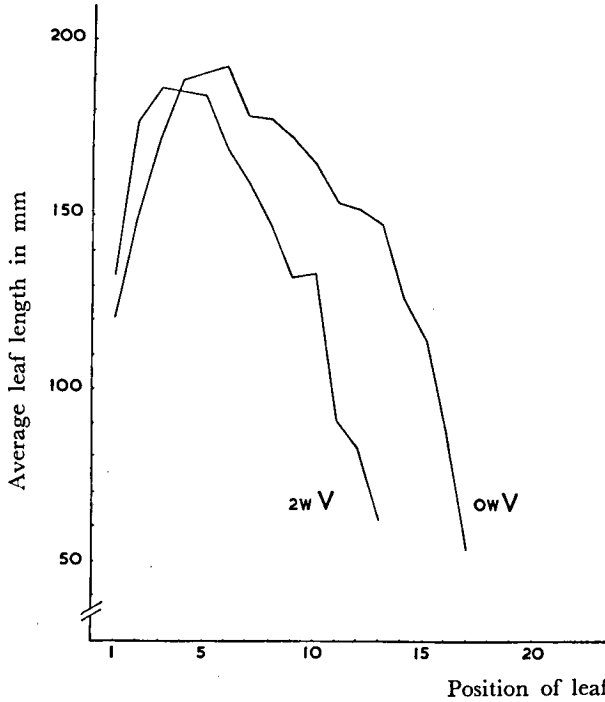


Fig. 1. Average length of mature leaves according to position on plants subjected to seed vernalization at 5° C during 0 or 2 weeks. Daylength: 16 hours (8 hrs strong light + 8 hrs weak light).

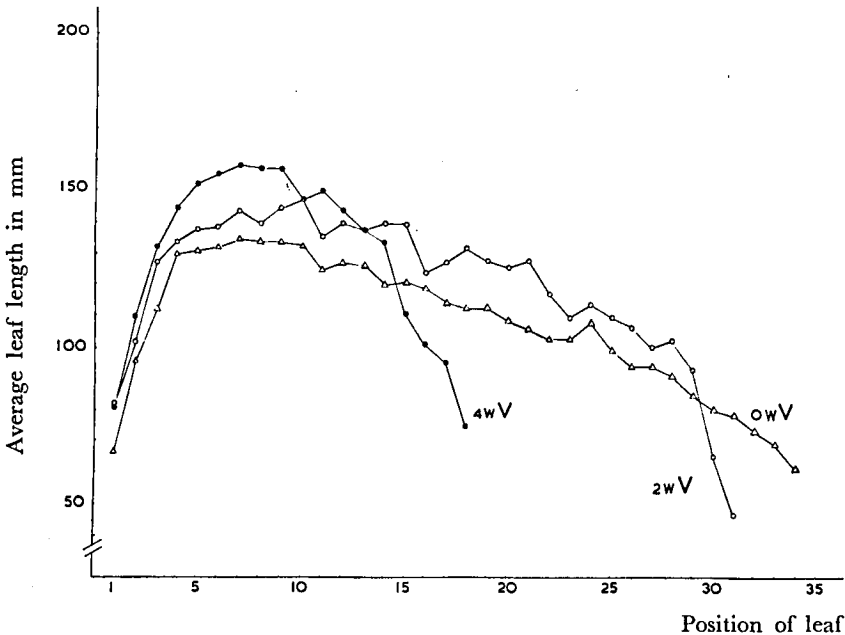


Fig. 2. Average length of mature leaves according to position on plants subjected to seed vernalization at 5° C during 0, 2 or 4 weeks. Daylength: 8 hours (strong light).

TABLE V  
Length/width-ratio of endive leaves under various conditions

Position of leaves Treatment	1-5	6-10	11-15
	Daylength 8 hours		
Unvernalized	1.95	1.80	1.77
2 weeks 5° C	1.93	1.89	1.86
6 weeks 5° C	1.77	1.73	1.76
	Daylength 16 hours		
Unvernalized	2.03	2.07	1.88
2 weeks 5° C	1.98	2.01	1.77

## DISCUSSION

The interesting fact about the influence of low temperature is that it does not become apparent until later, at a higher temperature. At the moment the seed is subjected to cold there are no leaf primordia present. Apparently low temperature induces a change in the apical meristem which is irreversible, at least under the conditions of the experiments described (WELLENSIEK, DOORENBOS and ZEEVAART, 1956). How far this may be said of the influence of daylength also is not yet known. The assumption that low temperature acts directly on the meristem, but that daylength exercises its effect via the leaves, seems reasonable but has not been proven. Further research on this point and on the many other problems that arise from the results under discussion is now in progress.

## SUMMARY

A study was made of the effect of seed vernalization and subsequent daylength on leaf number in vegetative plants of chicory and endive. In both species, vernalization and long day led to a marked decrease in number of leaves formed per unit of time. This corresponded with a decrease in fresh weight of the plant. The after-effects of low temperature on leaf morphology in chicory found by HARTMAN (1956) have been confirmed. In endive, vernalization leads to leaves that are longer, broader and thinner than those of unvernallized plants.

## REFERENCES

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