



HORTICULTURE RESEARCH INTERNATIONAL
STOCKBRIDGE HOUSE

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EARLY PRODUCTION OF BAGGED CRISP
AND CURLY LETTUCE UNDER GLASS

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Summary

Twelve crisp and curly lettuce varieties were grown at two CO₂ levels and with two ventilation temperatures in an experiment to evaluate the effect of environment on maturity date and quality. The 'novita' and curly types were the first to mature and the crisp varieties were the slowest.

Delayed ventilation shortened the time to maturity and the effect was most obvious on curly varieties and some of the crisp varieties. The use of CO₂ enrichment increased head weights but the effect was smaller than that of increased ventilation temperature. The benefits of the faster regime for individual varieties are discussed.

Objective

To evaluate the effect of two growing regimes on maturity date and quality of a range of crisp and curly lettuce varieties grown under glass for production in April and May.

Introduction

Outdoor crisp lettuce is produced from June onwards with some production in May where crop covers are used. Earlier in the year demand is met by imports. There is potential to replace imports with home produced lettuce grown in greenhouses for marketing during April and May. This would help to meet the increasing demand for crisp and curly types which is tending to replace the traditional butterhead requirement.

For the industry the production of bagged crisp or curly lettuce would result in better returns overall than from the marketing of butterhead lettuce.

This trial used 12 varieties in a low input slow-growing regime compared with a faster regime in order to determine the most suitable environment for production in April and May.

Materials and Methods

Treatments

Varieties:

		<u>Type</u>
Beatrice	NIZ	Crisp
Carvello	PTR	Crisp
Dorado	ENZ	Crisp
Globe	MOS	Crisp
Kellys	MOS	Crisp
Krizet	RZ	Oakleaf
LM8618	MOS	'Novita'
LM8630	MOS	'Novita'
Marshall	Yates	Crisp
Monet	RS	Curly
Novita	MOS	'Novita'
Olympus	RZ	Crisp

Environments

	<u>Temperatures</u>			<u>CO₂</u>
	<u>Day</u>	<u>Night</u>	<u>Vent</u>	
1.	7 °C	5 °C	10 °C	350 vpm
2.	7 °C	5 °C	10 °C	1000 vpm
3.	7 °C	5 °C	20 °C	350 vpm
4.	7 °C	5 °C	20 °C	1000 vpm

Culture

Sown: 24 January 1991

Planted: 13 March 1991

Spacing: 225 mm x 250 mm (9" x 10")

Design

The trial comprised of 48 treatments in a 4 environment x 12 variety factorial structure. The environments were divided into 2 vent temperature x 2 CO₂ level factorial. Three blocks with four compartments in each were used for the experiment and the environmental treatments were assigned to compartments on the basis of a 4 x 3 Youden square design. The 12 lettuce varieties were randomly allocated to each compartment in a 6 x 2 array. There were three replicates of all treatments.

Records

Three harvests were taken from each plot to represent an early, average and late cut. The dates were common for all replicates of a treatment but varied between treatments depending on the maturity of the crop. At each harvest 20 heads, together with surrounding guards were cut.

The following records were analysed:

Head weight
Weight of trimmings
Quality (Class I, II or Waste)

Throughout the growing period notes were made on growth habit of the crop.

Results

YIELD AND QUALITY

TABLE 1: HEAD WEIGHT (g)

The Effect of Ventilation Temperature

(Mean of CO₂ and varieties)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
Ventilation Temperatures			
10 °C	379.3	443.2	511.5
20 °C	394.8	455.5	522.4
SED (6 df)	10.67	7.07	10.47
LSD (P = 0.05)	-	-	-
Significance	NS	NS	NS

The Effect of CO₂

(Mean of varieties and ventilation temperatures)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
CO ₂ Enrichment Rate			
350 ppm	368.6	426.1	494.8
1000 ppm	405.6	472.7	539.1
SED (6 df)	10.67	7.07	10.47
LSD (P = 0.05)	26.1	17.3	25.6
Significance	*	***	*

KEY FOR TABLES

***	Significant at 0.1% level
**	Significant at 1% level
*	Significant at 5% level
NS	Not Significant

Mean head weight was increased by both higher ventilation temperature and CO₂ enrichment (see Table 1). At the optimum harvest stage (Harvest 2) high CO₂ levels led to an average increase in head weight of 46 g. The effect of ventilation temperature on head weight was not as pronounced but time to maturity was generally reduced (see Figure 4).

The difference in head weight between varieties was very highly significant (see Table 2). The crisp varieties were heavier than the 'novita' and curly types. Beatrice was the heaviest, followed by Marshall and Olympus. Monet and Krizet over matured very quickly and marketable weight at Harvest 3 was low due to senescence.

Of the 'novita' types there was little difference in head weight between Novita and LM 8630 but LM 8618 was much lighter at Harvests 1 and 2.

TABLE 2: HEAD WEIGHT (g)

The Effect of Variety

(Mean of CO₂ and ventilation temperature)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
Varieties			
Beatrice	534.4	619.4	674.8
Carvello	437.2	499.0	569.1
Dorado	349.6	423.3	536.1
Globe	442.5	490.2	580.3
Kellys	454.5	486.6	586.2
Krizet	306.6	347.3	366.1
LM 8618	273.2	339.2	414.1
LM 8630	301.7	377.5	408.3
Marshall	477.1	555.2	635.6
Monet	323.7	379.3	402.6
Novita	284.8	360.9	438.5
Olympus	459.8	514.5	591.6
SED (86 df)	22.36	22.39	27.20
LSD (P = 0.05)	44.5	44.6	54.2
Significance	***	***	***

TABLE 3: PERCENTAGE TRIMMINGS (by weight)

The Effect of Ventilation Temperatures

(Mean of CO₂ and varieties)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
Ventilation Temperature			
10 °C	3.6	3.9	4.0
20 °C	3.7	4.0	4.3
SED (3 df)	0.07	0.10	0.08
LSD (P = 0.05)	-	-	-
Significance	NS	NS	NS

The Effect of CO₂

(Mean of varieties and ventilation temperatures)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
CO ₂ Enrichment Rate			
350 ppm	3.5	3.9	4.0
1000 ppm	3.7	4.0	4.2
SED (3 df)	0.07	0.10	0.08
LSD (P = 0.05)	-	-	-
Significance	NS	NS	NS

The amount of trimming required was low but increased at each harvest and there was no evidence of significant differences between ventilation temperatures or CO₂ levels (see Table 3).

Variety was the factor most significantly influencing the amount of trimming required (see Table 4). Krizet, a loose oakleaf type required a large amount of trimming on all three harvest dates, but Monet a curly variety was one of the better varieties at the first two harvests. By Harvest 3 it was overmature and therefore required more trimming.

Beatrice produced a large loose head which always needed a lot of trimming and Globe was also poor in this respect. LM 8630 needed very little trimming at the first harvest but deteriorated quickly and was poor at Harvests 2 and 3. Dorado was consistently one of the varieties requiring the least trimming.

TABLE 4: PERCENTAGE TRIMMINGS (by weight)

The Effect of Variety

(Mean of CO₂ and ventilation temperature)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
Varieties			
Beatrice	4.5	4.1	4.3
Carvello	3.6	3.8	4.0
Dorado	3.2	3.3	3.6
Globe	4.0	4.1	4.0
Kellys	3.6	3.8	3.8
Krizet	4.4	5.3	5.6
LM 8618	3.4	3.7	3.9
LM 8630	2.7	4.0	4.4
Marshall	3.7	3.7	3.6
Monet	3.3	3.7	4.3
Novita	3.4	3.6	3.9
Olympus	3.9	3.9	3.9
SED (88 df)	0.22	0.27	0.22
LSD (P = 0.05)	0.4	0.5	0.4
Significance	***	***	***

TABLE 5: PERCENTAGE CLASS I

The Effect of Ventilation Temperatures

(Mean of CO₂ and varieties)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
Ventilation Temperatures			
10 °C	99.0	96.2	86.4
20 °C	95.5	92.8	83.3
Standard Deviation			
10 °C	2.74	10.69	29.36
20 °C	15.85	18.14	28.37

The Effect of CO₂

(Mean of varieties and ventilation temperatures)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
CO ₂ Enrichment Rate			
350 ppm	96.9	95.2	86.7
1000 ppm	97.6	93.8	83.0
Standard Deviation			
350 ppm	13.91	13.66	29.00
1000 ppm	8.44	16.16	28.70

Note:

Standard deviation should not be used to determine differences between treatments but give some guide about the variability within each treatment.

TABLE 6: PERCENTAGE CLASS I

The Effect of Variety

(Mean of CO₂ and ventilation temperature)

	<u>Harvest 1</u>	<u>Harvest 2</u>	<u>Harvest 3</u>
Varieties			
Beatrice	75.3	63.8	20.7
Carvello	99.5	95.8	82.7
Dorado	97.6	95.2	83.7
Globe	100.0	94.3	89.2
Kellys	98.6	100.0	87.7
Krizet	100.0	95.3	90.2
LM 8618	99.5	95.3	91.7
LM 8630	99.5	99.5	96.7
Marshall	99.0	96.7	87.7
Monet	100.0	98.5	99.1
Novita	98.6	99.5	98.5
Olympus	99.5	100.0	90.1
Standard Deviation			
Beatrice	32.71	27.48	26.53
Carvello	1.73	10.31	29.46
Dorado	4.58	9.35	26.68
Globe	0.00	16.02	28.56
Kellys	3.48	0.00	9.25
Krizet	0.00	16.17	20.42
LM 8618	1.73	14.38	28.87
LM 8630	1.73	1.73	11.26
Olympus	1.73	0.00	13.08
Marshall	2.34	6.06	28.40
Monet	0.00	2.71	3.18
Novita	3.48	1.73	2.71

Overall quality was good although percentage Class I was lower at later harvests. Higher ventilation temperatures tended to reduce quality and also increased variability at the earlier harvests (see Table 5).

High CO₂ levels had less effect on quality but generally led to a reduction in Class I heads at Harvests 2 and 3. CO₂ enrichment reduced variability at the first harvest.

At Harvest 1 only Beatrice produced less than 95% Class I heads and quality was also very poor at Harvests 2 and 3 from this variety.

Novita and LM 8630 produced good quality heads throughout but LM 8618 was slightly poorer.

Krizet and Monet were both excellent at Harvest 1 with 100% Class I. Thereafter Monet remained good but quality of Krizet fell as it overmatured.

All of the crisp varieties except Beatrice gave excellent quality at Harvest 1 and Olympus and Kellys were also 100% Class I at Harvest 2 although quality from the other varieties fell slightly. Olympus and Globe were the best quality varieties at Harvest 3 (see Table 6).

Average leaf colour, frame size and head density of the varieties is illustrated in Figures 1-3.

FIGURE 1: LEAF COLOUR
(Score 0-5, where 0 is pale and 5 is dark green)

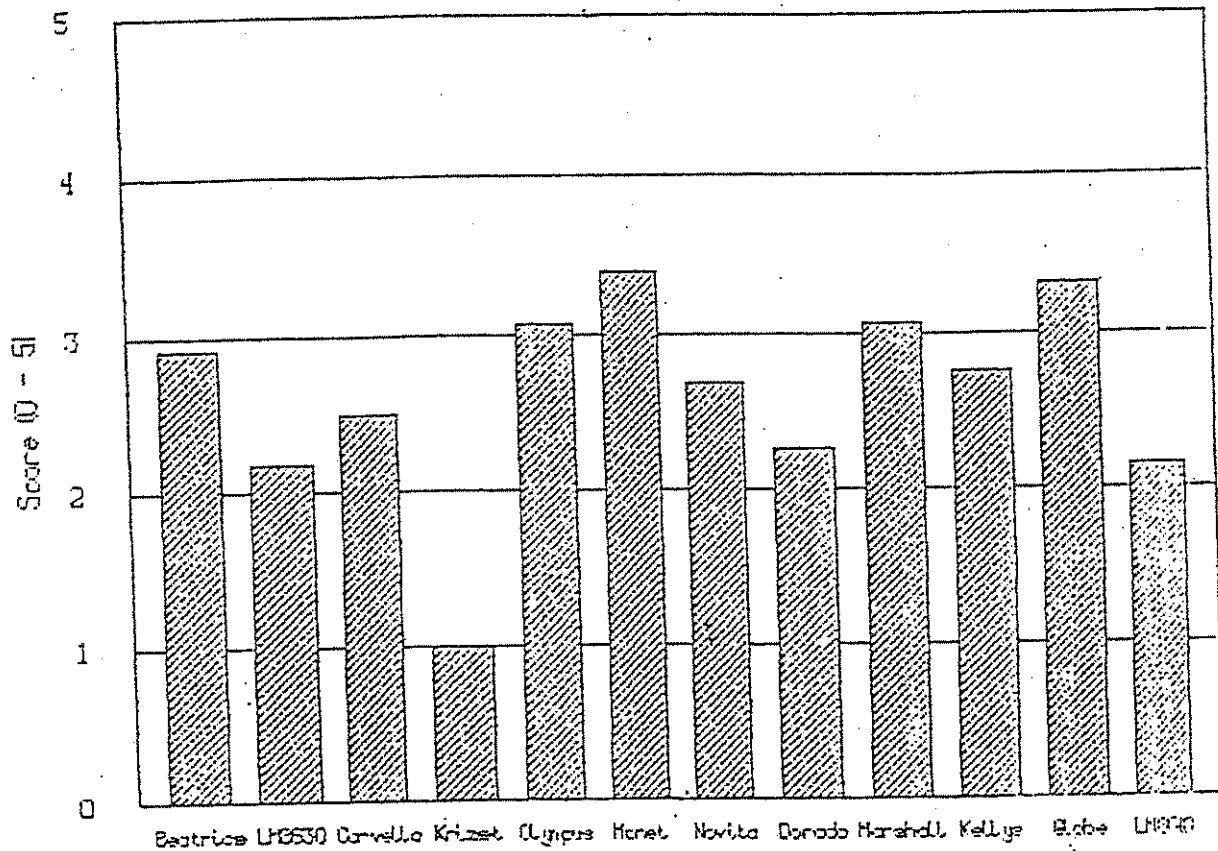


FIGURE 2: FRAME SIZE

(Score 0-5, where 0 is small and 5 is very large)

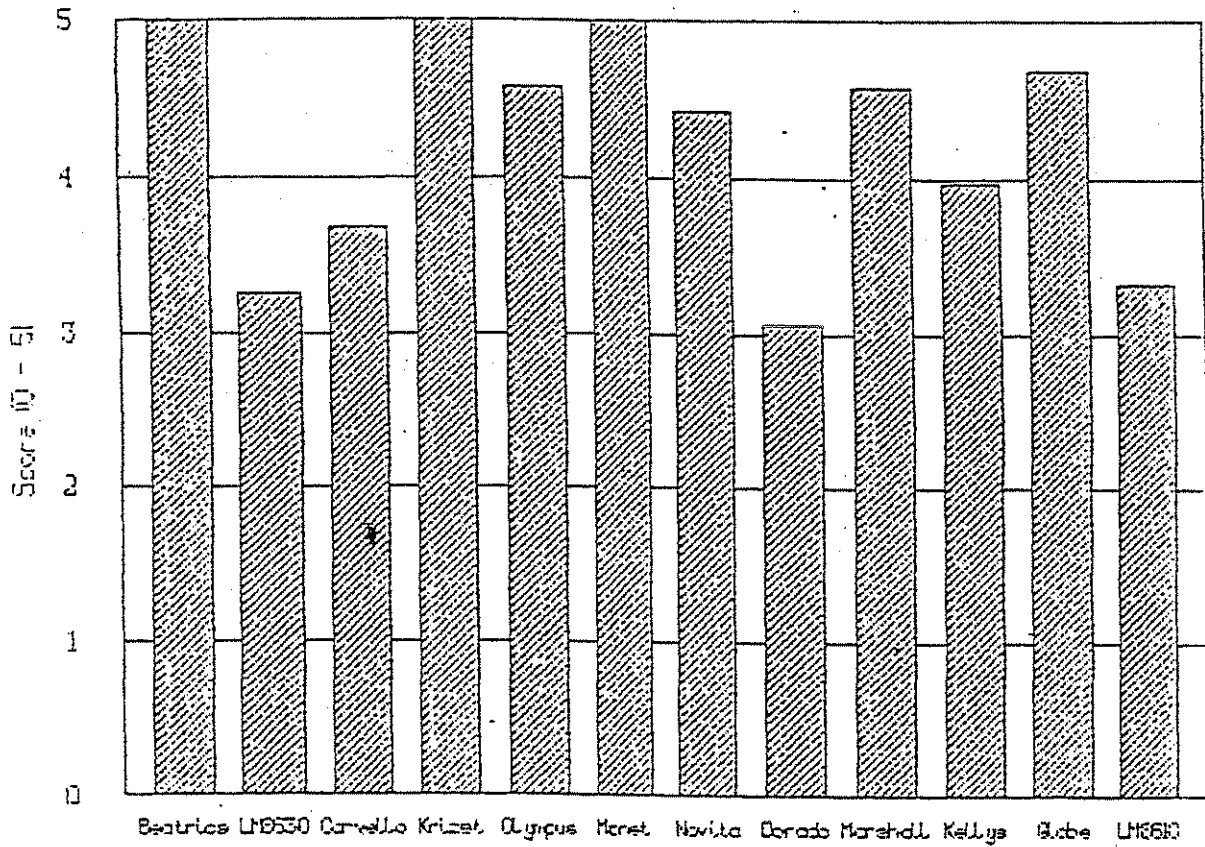
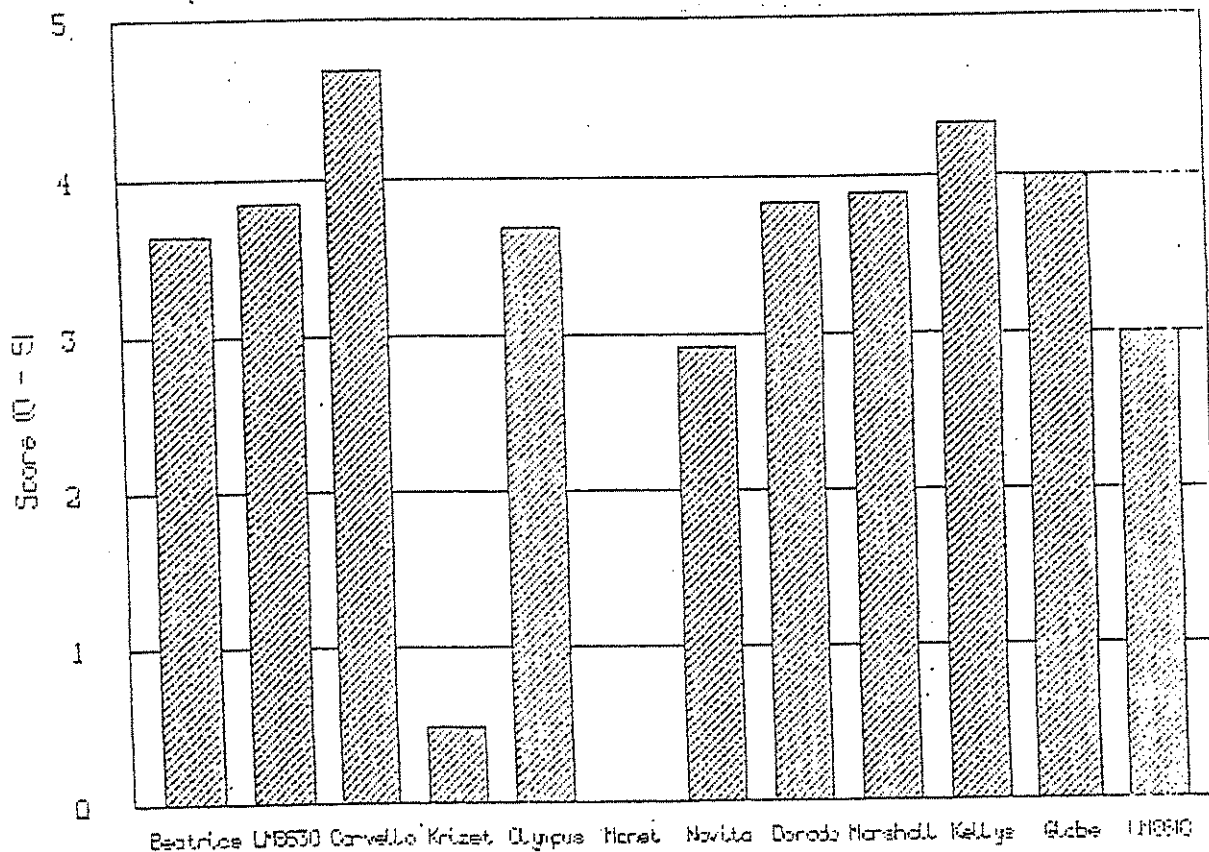


FIGURE 3: HEAD DENSITY

(Score 0-5, where 0 is loose and 5 is very dense)



Maturity Date

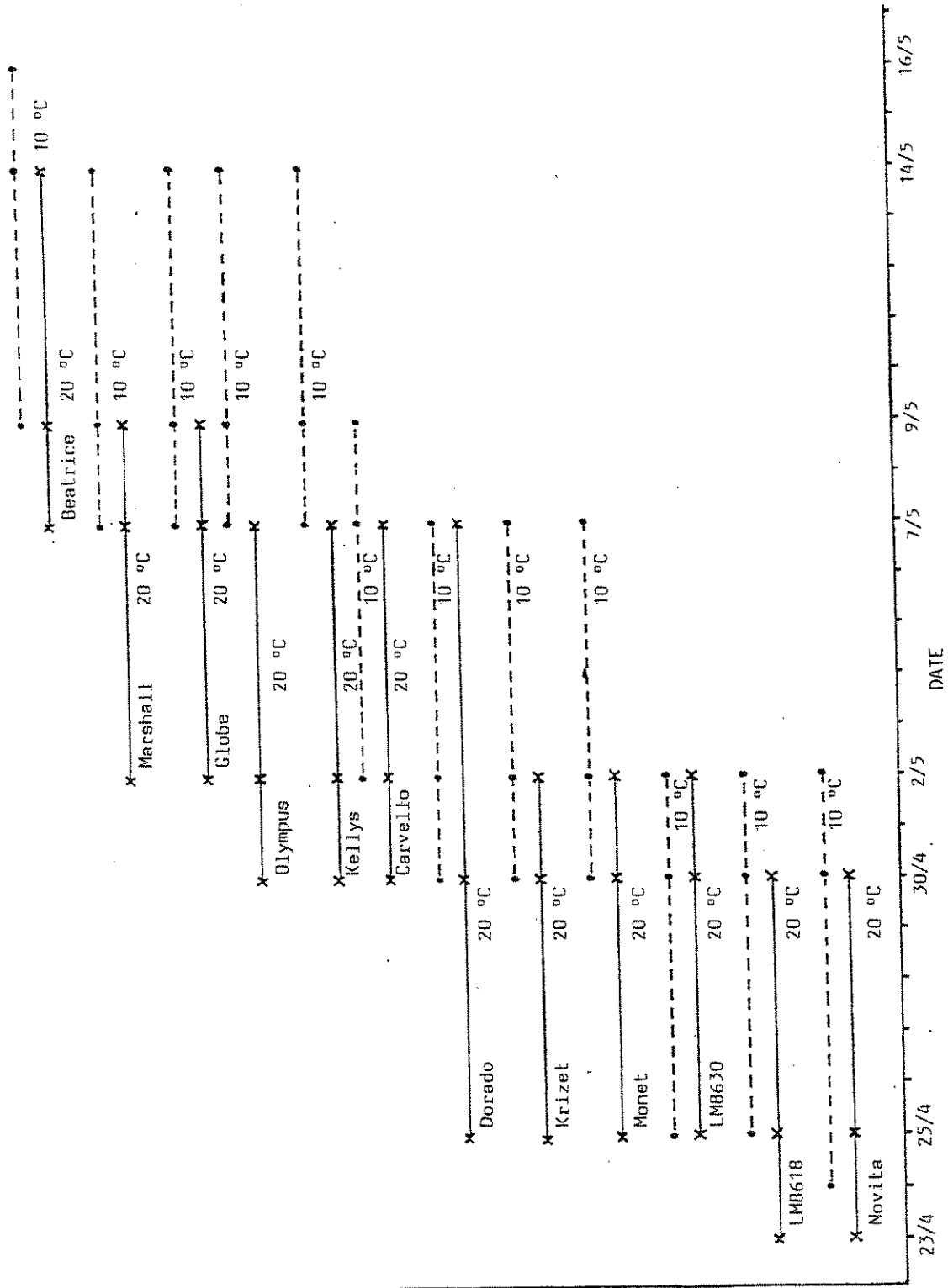
Figure 4 shows the periods over which each variety was harvested and the difference between the two temperature regimes. Early, optimum and late harvest dates are indicated.

The 'novita' types were the first to reach maturity, with LM 8618 and Novita on 23 April and LM 8630 two days later. A ventilation temperature of 10 °C delayed maturity for LM 8618 and Novita but not for LM 8630.

Krizet and Monet with 20 °C vent temperature matured at the same time as the 'novita' types. Lower temperatures delayed first harvest by five days for these varieties.

The crisp varieties were the slowest to mature, the first being Dorado with a first harvest date of 25 April. Beatrice was the slowest variety with first harvest on 7 May, 12 days later than Dorado. Lower ventilation temperatures delayed maturity for two to seven days for the crisp varieties (see Figure 4).

FIGURE 4: HARVEST PERIOD



Environment

Heating temperature was set at 7 °C day and 5 °C night but the ventilation setpoint treatments led to variations in achieved average temperatures between the treatments due to delayed ventilator opening. Increasing the setpoint for ventilators to open from 10 °C to 20 °C increased the average temperature by 1 °C (see Figure 5).

Figure 6 shows the difference in average temperature caused by the delay in ventilation.

FIGURE 5: AVERAGE 24 HOUR TEMPERATURES

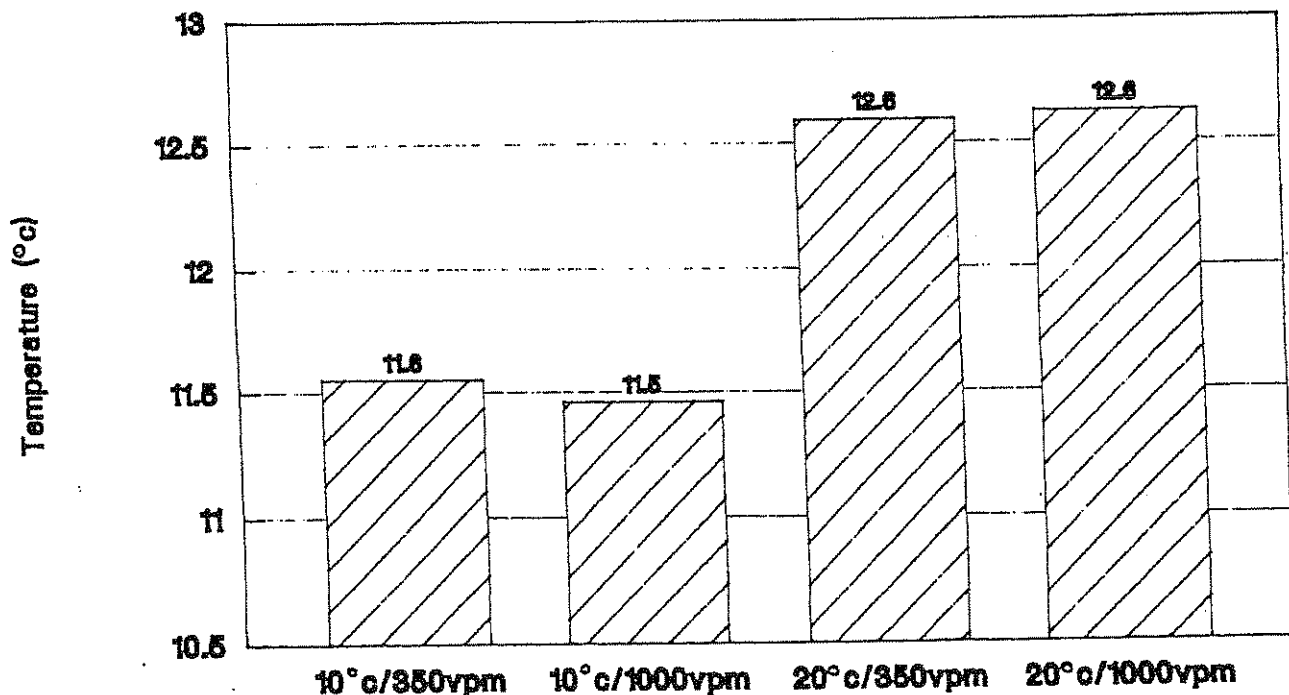
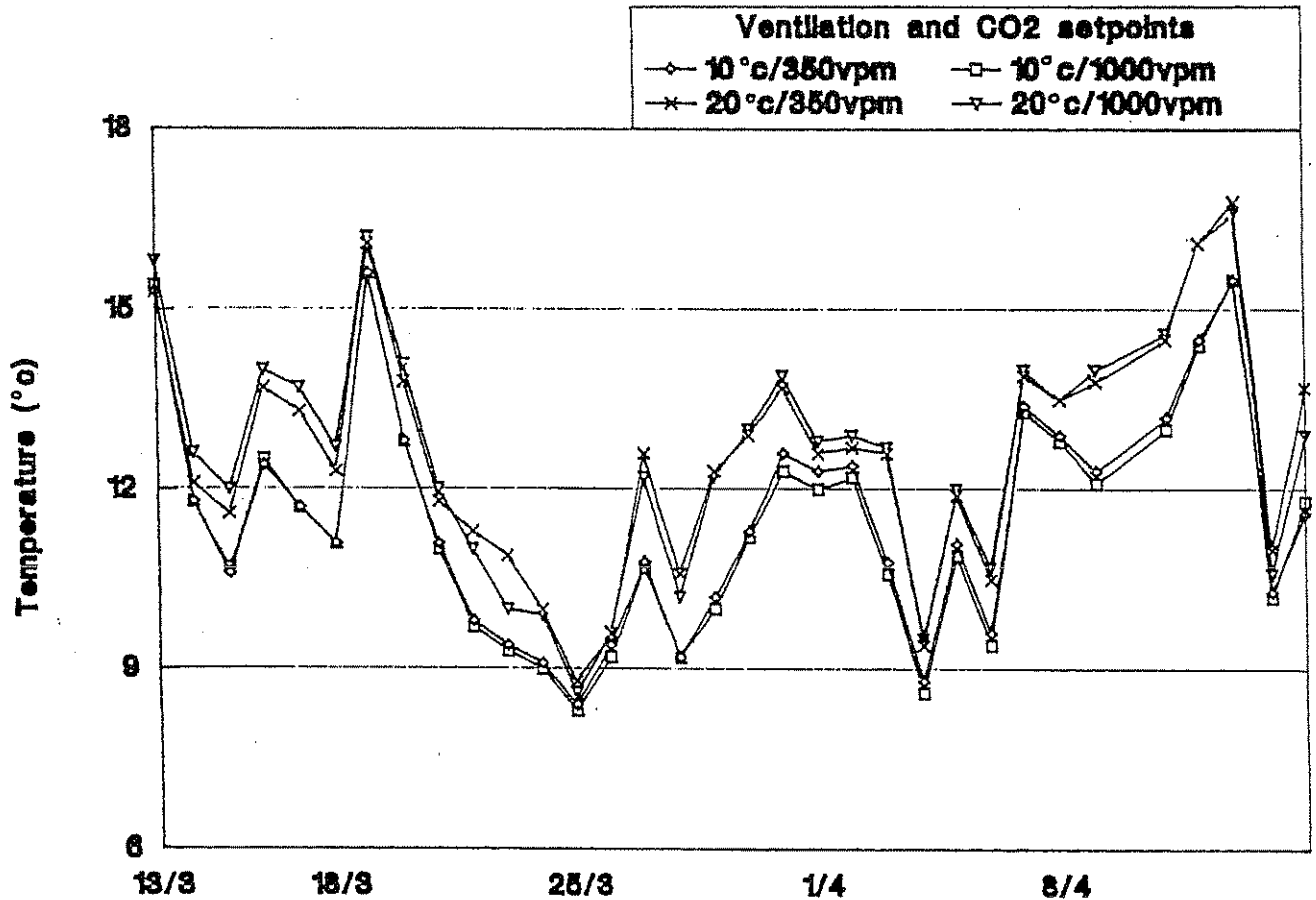


FIGURE 6: TEMPERATURE



The ability to maintain CO₂ levels was also influenced by ventilation temperature setpoint. Average daytime levels were above ambient in the 350 vpm treatment and a vent setpoint of 20 °C gave on average 34 vpm more than the 10 °C setpoint.

It was not possible to maintain 1000 vpm. With a 10 °C vent temperature average daytime CO₂ level was 655 vpm but at 20 °C vent this rose to 733 vpm (see Figure 7). Enrichment continued regardless of ventilator position.

The effect of ventilation temperature on achieved CO₂ level was twice as high when aiming for 1000 vpm than at the lower target level.

FIGURE 7: ACHIEVED CO₂ LEVELS

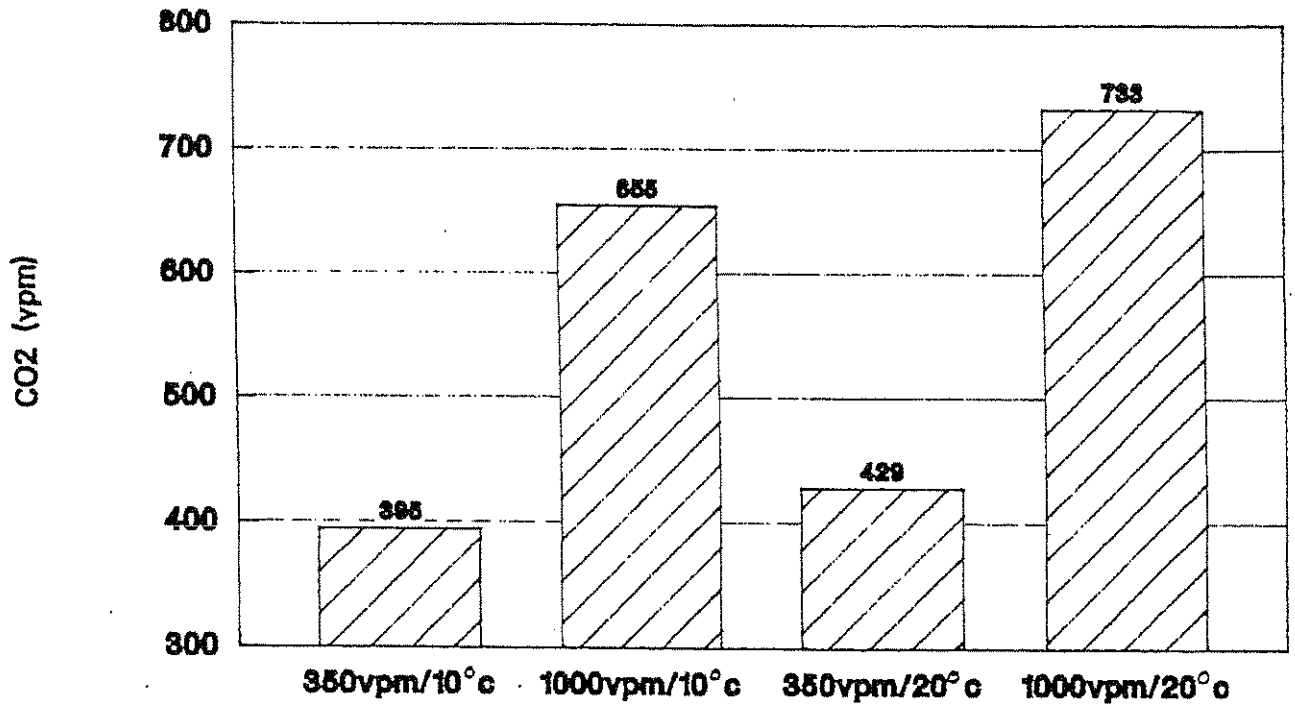
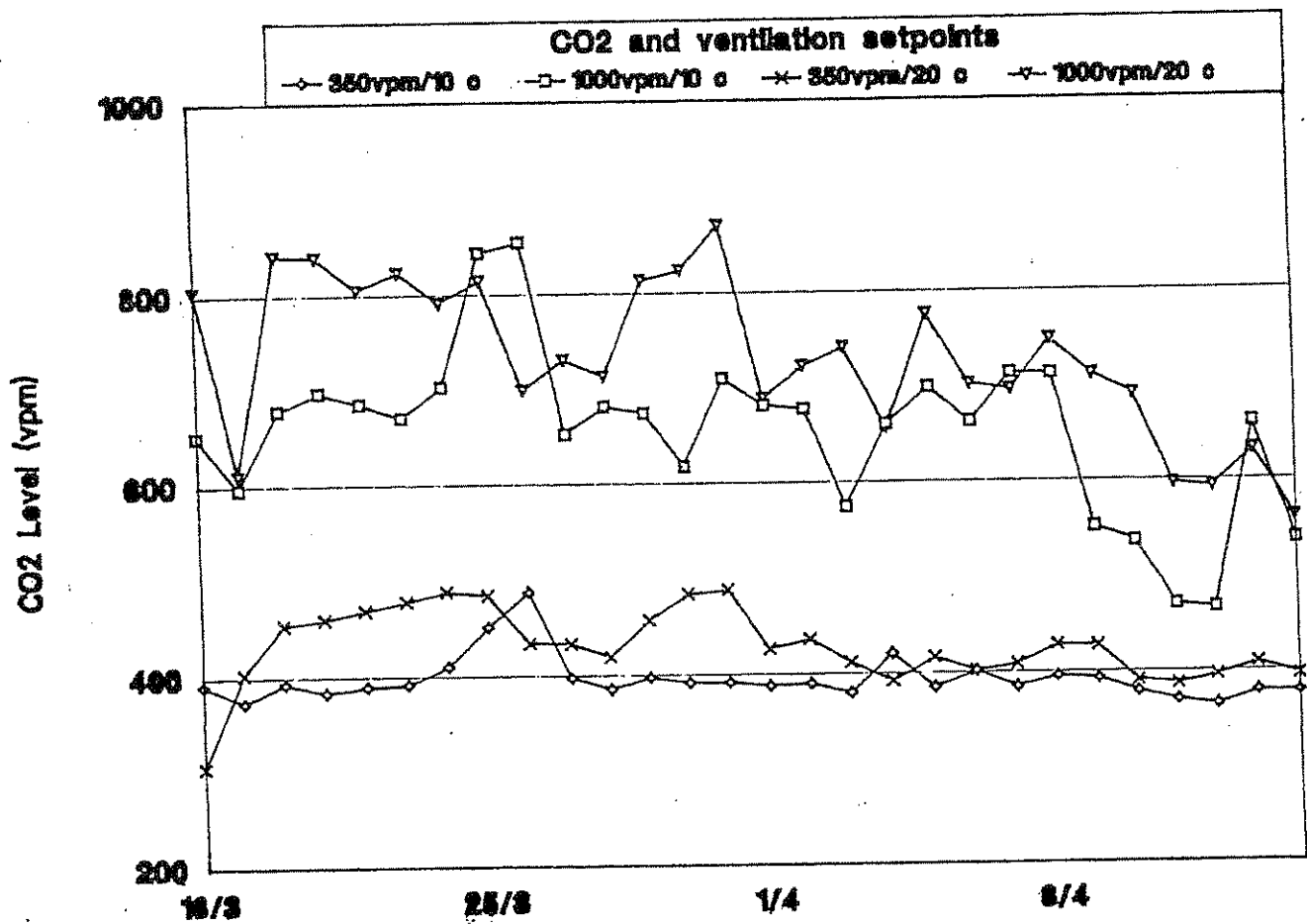


FIGURE 8: CO₂ LEVEL



Discussion

Use of a higher ventilation temperature increased average temperatures by approximately 1 °C and helped maintain higher CO₂ levels. Maturity dates were brought forward by up to seven days. The period from first to third harvest was not reduced with the higher temperature regime.

The effect on crisp and curly varieties was generally larger than on 'novita' type varieties.

There was no effect on head weight or percentage trimmings but there was an indication that higher ventilation temperatures could reduce the percentage of heads in Class I.

Higher CO₂ levels did not influence date of maturity but gave increased head weights. Trimming required was not affected and effect on head quality was small.

The most important factor influencing maturity date and quality was choice of variety.

The varieties used in this trial could be divided into three groups.

- a) 'Novita' types
- b) Curly
- c) Crisp

'Novita' Types

In this group were Novita, LM 8630 and LM 8618. These were the earliest varieties to mature. Use of increased ventilation temperature gave a maximum of two days earlier maturity.

Novita was the most uniform with both LM 8630 and LM 8618 showing variability in head size and curliness. Novita had the largest frame size (Figure 2) of the three but LM 8630 produced heads with the highest density (Figure 3).

All of the 'novita' types tended to be rather "ribby". LM 8630 had a particularly thick stem. Colour was pale green compared with the crisp types (Figure 1).

Overall, neither of the new varieties was better than Novita for earliness or quality.

Curly Types

Krizet and Monet are both curly 'novelty' type varieties. Maturity date and harvest periods were the same but Krizet overmatured quickly and quality was less good at the third harvest. Higher ventilation temperature brought forward the first harvest by six days.

Both varieties were very large framed and did not form a heart. Krizet was very pale green although the colour was darker in the cooler treatment. The base was very loose and the variety had a tendency to produce shoots. Flavour was excellent.

Monet was a darker green with long narrow very curly leaves. It was very upright with a loose narrow pointed base. Some glassiness in the centre was observed.

Crisp Types

The crisp types were the slowest to mature but produced the heaviest heads. The effect of warmer temperatures was variable, ranging from two days to seven days earlier maturity.

Dorado was the earliest to mature and at 20 °C had a very long maturity period of 12 days from first to third harvests. It was a very small framed pale/mid green variety. There was some variability in size and density. The heart was slightly pointed and the base well filled and upright with prominent ribs. The heart density was moderate for a crisp variety and the heads looked rather untidy when bagged.

Olympus, Kellys and Carvello all matured together after Dorado when grown with 20 °C ventilation temperature but when grown at the cooler temperature maturity was spread out (see Figure 4). At 10 °C vent temperature Olympus did not begin to mature until six days after Carvello. Kellys was between the two.

Carvello had a fairly small frame with a flat solid base. The heart was round and very dense. The leaf was mid green with a strong bubble and a less serrated edge than many crisp varieties. There was some loss of quality at Harvest 3 due to slight stem elongation.

Kellys was a very good quality variety with a fairly small frame and slightly pointed dense hearts. Uniformity was excellent. Leaf colour was mid green with a slight bubble but a very ragged leaf edge. The base was solid and flat with prominent ribs.

Olympus produced good quality heavy heads but was less dense than other varieties and had a rather ugly shape. It was very ribby with a thick stem and a solid slightly pointed base. Leaf colour was medium green with moderate bubble and a ragged edge. There was slight variability.

Marshall and Globe were later maturing. Marshall gave heavy heads but they were often untidy, ribby, mis-shaped and twisted. Hearts were pointed and density was not good. Frame size was medium and colour fairly dark. Uniformity was good.

Globe was another rather untidy variety that required a lot of trimming. It had a medium frame with rather pointed hearts and a pointed base. Density was better than Marshall. Uniformity was good.

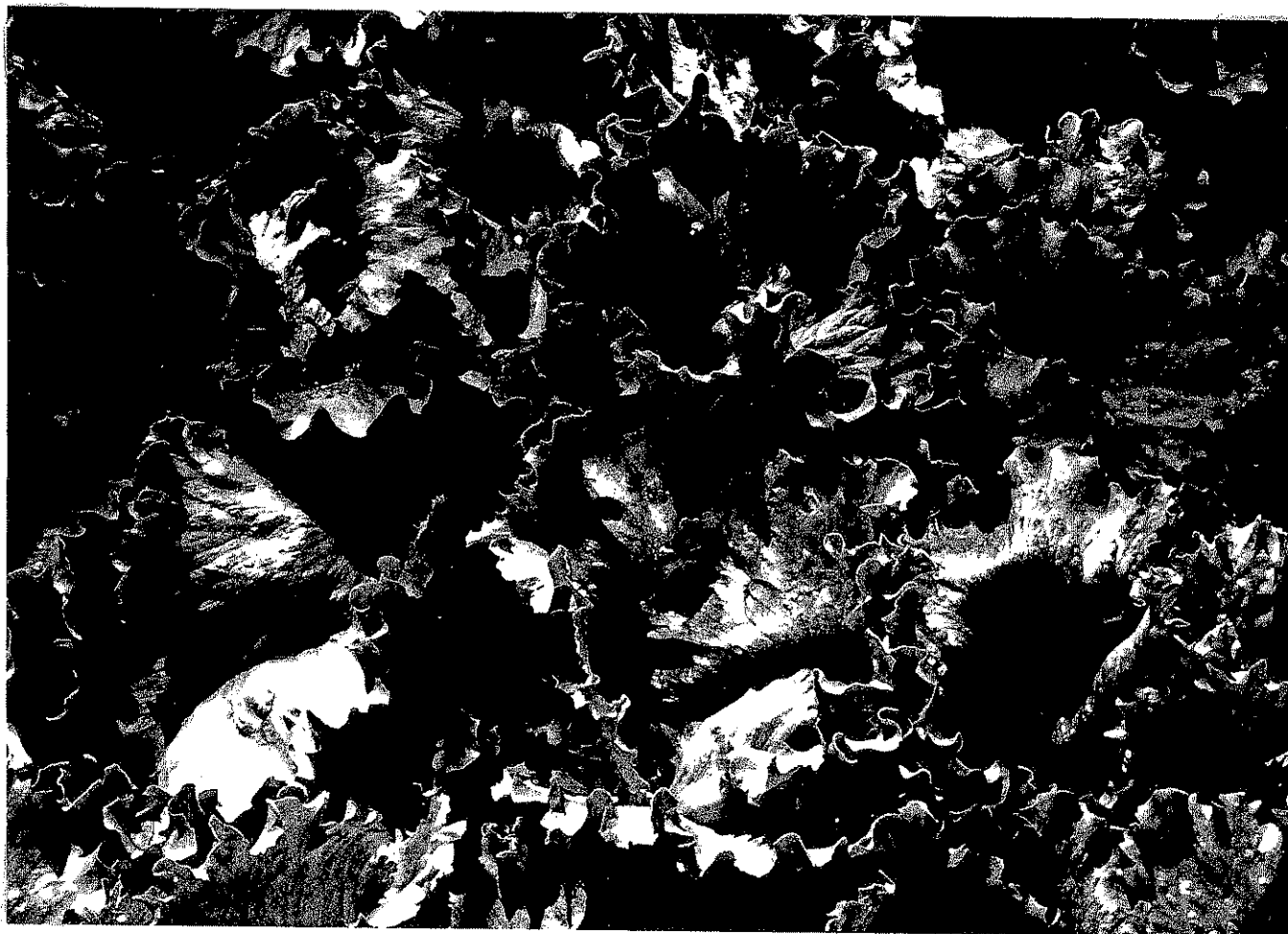
Beatrice was very slow to mature and produced very big heavy heads. Quality was poor and the heads were very untidy with poor density. Colour was very bright green. The base was small and pointed with some extension of the stem and twisting. Overall a poor variety despite its size.

Conclusions

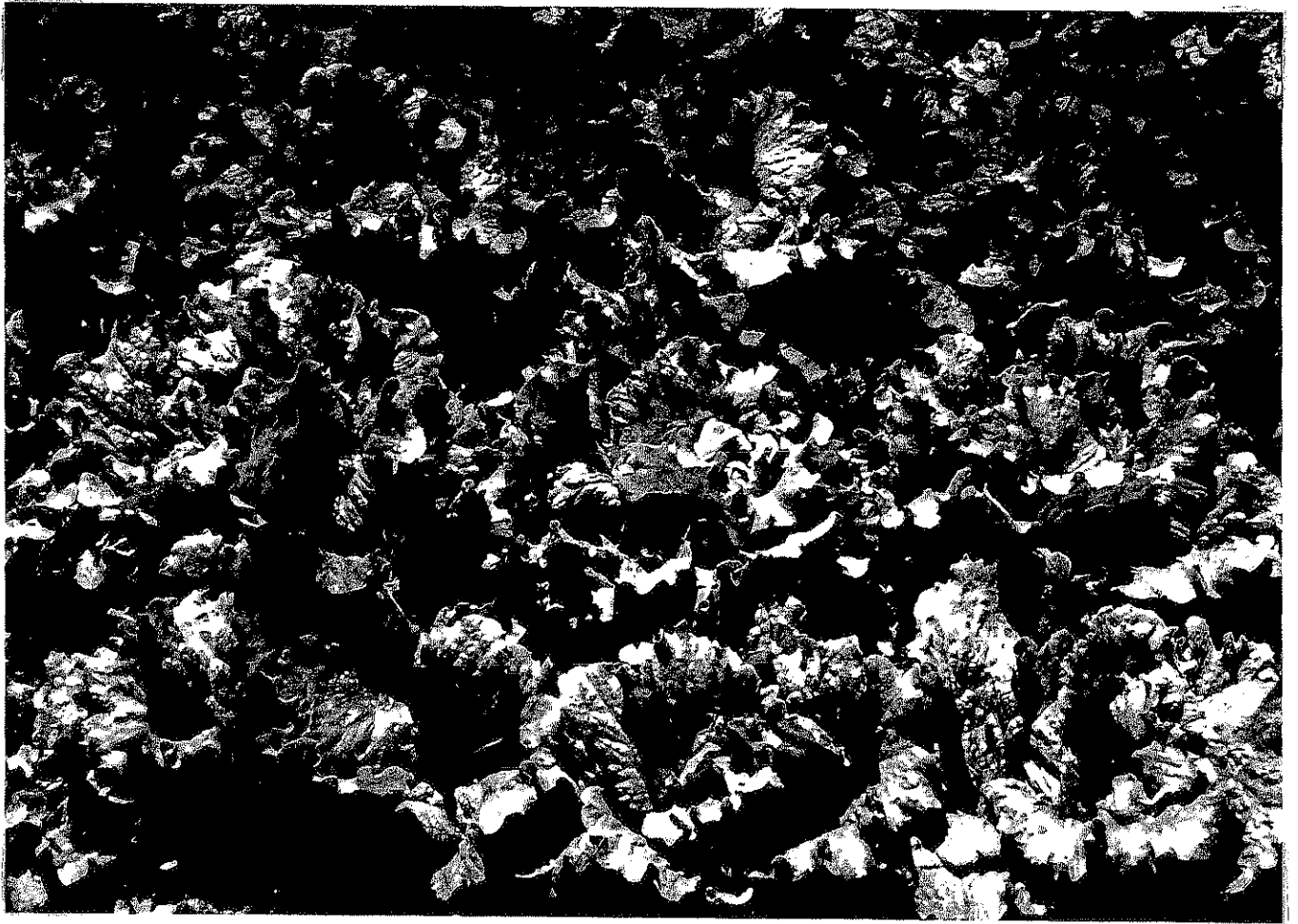
1. Raising ventilation setpoint from 10 °C to 20 °C increased achieved average temperature by 1 °C.
2. Delayed ventilation increased CO₂ levels by 8% in the 350 vpm treatment and 11% in the 1000 vpm treatment (Note: 1000 vpm was not achieved).
3. Delayed ventilation generally reduced the time to maturity, the amount being variable with variety.
4. Higher CO₂ levels increased head weights.
5. Novita types were the quickest to mature, followed by the curly varieties and then the crisp types.
6. From a 24 January sowing the maturity period ran from 23 April to 16 May.
7. Benefits of the faster growing regime were highest for curly varieties and some of the crisp types.

APPENDIX: PHOTOGRAPHS

1. Beatrice



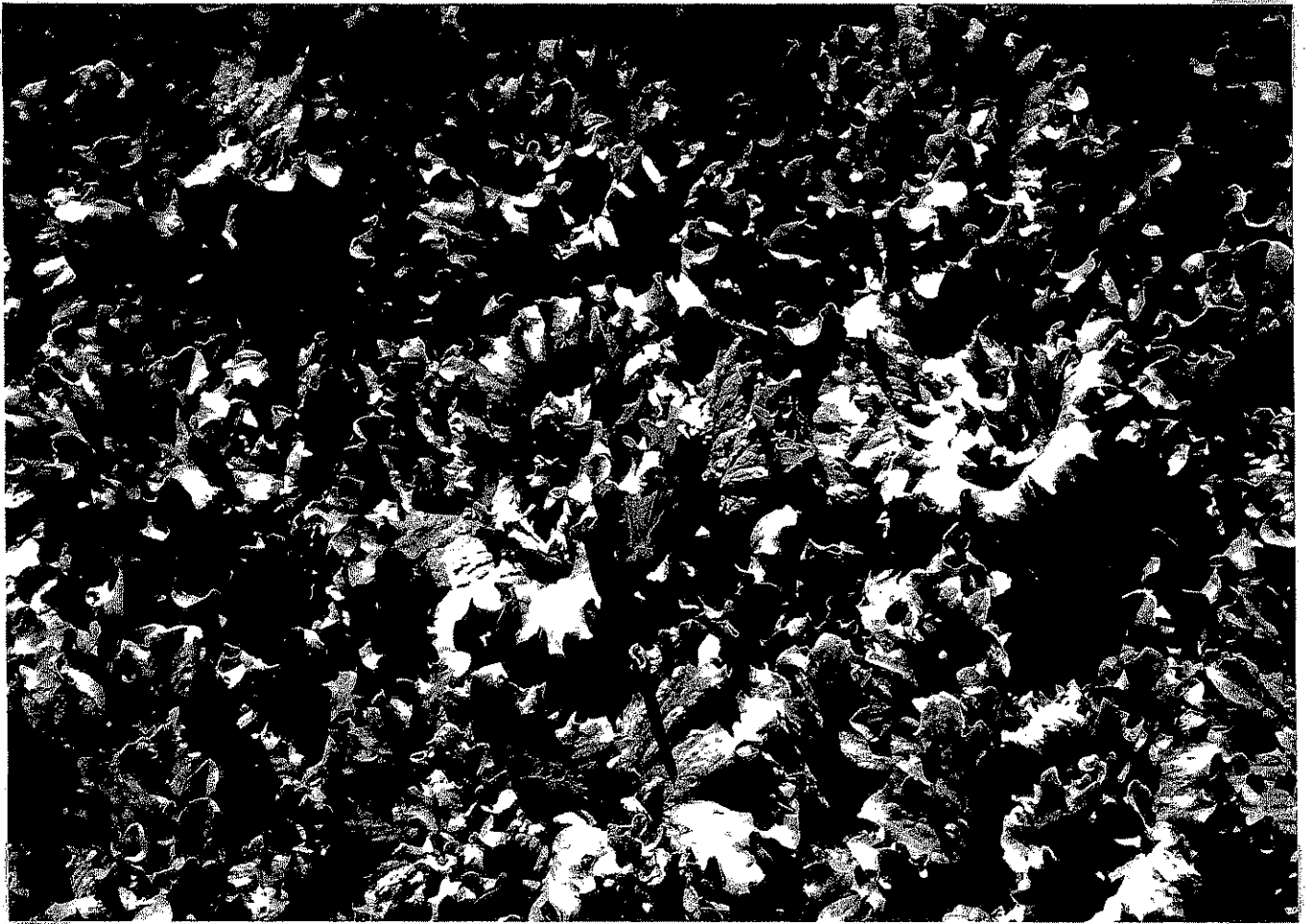
2. Carvello



3. Dorado



4. Globe



5. Kellys



6. Krizet



7. LM 8618



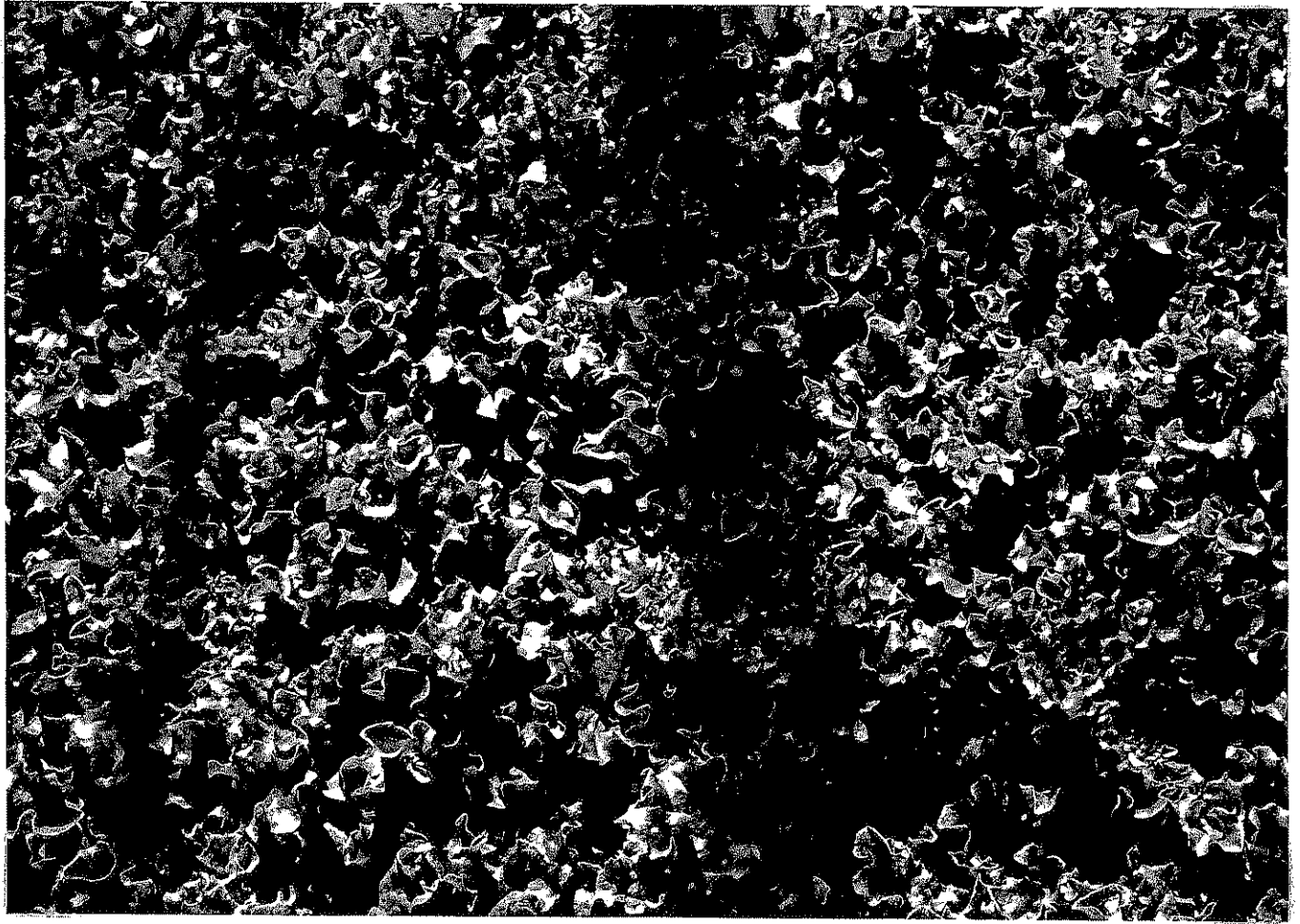
8. LM 8630



9. Marshall



10. Monet



11. Novita



12. Olympus

