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New greenhouse vegetable crops for growing in the winter season – Pakchoy

Nye grønsagskulturer til væksthus om vinteren – Pakchoy

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Summary

Since 1981 the Institute of Glasshouse Crops, Årslev, has performed trials with different vegetable crops for growing at low temperatures (5°C) in the winter season (mid September to mid February).

One of the most promising crops is pakchoy. The trials included varieties, transplant size, plant spacing, temperature regimes, soil heating and substrates.

There was no difference in production or appearance between the two varieties 'AH 1005' and 'Japro'.

By increasing the size of the transplants from four to six true leaves it is possible to shorten the cultivation period after transplanting.

A plant spacing of 25 × 25 cm improves earliness, average weight per plant and per cent marketable plants compared to 20 × 25 cm.

The temperature experiment showed that it is possible to grow pakchoy in the autumn/winter at a min. temperature of 5°C. By raising the temperature the time to harvest is reduced.

There was a positive effect of soil heating on the growth of pakchoy, especially at a low air temperature regime.

Plant growth was retarded on 4 cm thick rockwool mats, and the average weight per plant was lower and the harvest was later than for soil grown plants.

Key words: *Brassica chinensis,* pakchoy, varieties, transplant size, sowing dates, spacing, temperature regimes, soil heating, growing media.

Resumé

På Institut for Væksthuskulturer har man i en række forsøg undersøgt, hvilke grønsagskulturer, der egner sig til dyrkning fra midten af september til midten af februar ved lave temperaturer (5°C nat). En del af forsøgene er beskrevet i artikler i Gartner Tidende (se sidst i beretningen).

Pakchoy var en af de mest lovende kulturer. Forsøgene omfattede sorter, størrelser på udplantningsplanter, planteafstande, temperaturprogrammer, jordvarme og dyrkningsmedier.

Der var ingen forskel i udbytte og udseende mellem de to sorter 'AH 1005' og 'Japro'.

Ved at så tidligere og dermed udplante større planter kan kulturtiden efter udplantning forkortes. Ved en formeringstid på 5 uger (5–6 blade) bliver tidligheden og plantevægten forbedret i forhold til 4 ugers formering (4–5 blade). Udplant-

ningen af planter med 5–6 blade var dog vanskelig.

En planteafstand på 25 × 25 cm (16 pl. pr. m^2) fremmer tidligheden, plantevægten og procent fejlfri planter i forhold til en afstand på 20 × 25 cm (20 pl. pr. m^2).

Temperaturforsøget viste, at pakchoy kan dyrkes om efteråret og om vinteren ved en min. lufttemperatur på 5°C. Ved at hæve lufttemperaturen er det dog muligt at forkorte vækstperioden.

Der var en positiv effekt af at hæve jordtemperaturen til 15°C, specielt ved lave lufttemperaturer.

Dyrkning på tynde stenuldsmåtter gav mindre planter og senere høst i forhold til dyrkning på jord.

Nøgleord: *Brassica chinensis*, pakchoy, sorter, udplantningsplantens størrelse, sådato, planteafstand, temperaturprogram, jordtemperatur, dyrkningsmedie.

Introduction

Pakchoy *(Brassica chinensis)* is a new vegetable crop on the Danish and European market. However, it was described in Denmark already in 1884 by *Samsøe-Lund* and *Kjærskow* (8) by the name pak-choi.

Pakchoy originates from East-Asia. It is closely related to the chinese cabbage, but in growth habit and appearance it is more like swiss chard *(Beta vulgaris var. cycla)*. The petiole is broad, thick, crisp and shining white. The foliage is dark green with a thick white central rib and white leaf veins.

The taste of pakchoy is somewhat like chinese cabbage, but milder.

Pakchoy is fast growing even at low temperatures and low light intensities, and is therefore suitable for growing in the autumn and winter in a glasshouse as a supplement to a tomato or a cucumber crop. Pakchoy can also be an alternative to a lettuce crop, because it thrives in the same growing conditions.

The aim of the experiment was to study the effect of variety, transplant size, plant spacing, temperature regime, soil heating and substrate on growth and yield of pakchoy.

Method

Experimental design

The plants were grown in a glasshouse with six compartments, each of 68 m^2. The experiments were designed as complete factorial experiments with three replicates and 24 plants per replicate. In 1984 two crops were cultivated sequentially with planting on the 17 September and 13 November respectively. In 1985 the whole experiment was planted on 10 October.

In 1984 the two experiments incorporated the following treatments: Varieties, transplant size, plant spacing, temperature regimes, soil heating and substrates. The first crop included two different transplant ages (sown 20 August and 27 August), but not soil heating. The second crop (sown 8 October) included soil heating, but not different transplant ages.

The experiment in 1985 incorporated the following treatments: plant spacing, transplant size, temperature regime and soil heating.

The experimental details for 1984 and 1985 are summarized in Tables 1, 2 and 3 respectively.

Propagation

The seeds were sown in pressed peat blocks and covered with gravel. The peat blocks were 5×5 cm in 1984 and 6×6 cm in 1985. The temperature was 20°C in 1984 and 17°C in 1985 until germination and thereafter 10°C at night and 15°C at day with ventilation at 25°C in 1984 and 20°C in 1985.

During propagation the plants were watered with a 1.8‰ nutrient solution.

Growing conditions

The plants were planted in a limed, well fertilized and watered soil, cultivated to 15 cm depth. When growing on rockwool two 2 cm thick rockwool mats were put on top of each other on plastic covered ground.

Soil and rockwool were covered with white plastic with 10 × 10 cm holes.

The plants were watered with a 1.8–1.9‰ nutrient solution. Plants in the soil were watered by hose and plants on rockwool by drip irrigation.

In 1985 the plants were given 1000–1100 ppm CO_2 when the windows were closed.

Table 1. Pakchoy. Treatments in 1984.
Forsøgsbehandlinger i 1984.

	First Crop	Second Crop
Varieties	1. 'Japro' 2. 'AH-1005'	1. 'Japro' 2. 'AH-1005'
Transplant age	1. 3 week 2. 4 week	–
Plant spacing	1. 20×25 cm 2. 25×25 cm	1. 20×25 cm 2. 25×25 cm
Soil heating	–	1. No soil heating 2. 14°C
Substrates	1. Rockwool mats 2. Soil	1. Rockwool mats 2. Soil

Temperature regime	Min. night	Min. day	Light addition	Venti-lation		Min. night	Min. day	Light addition	Venti-lation*
1. low*:					1. low:				
First 3 weeks	2°C	2°C	0°C	+10°C	First week	10°C	10°C	+ 4°C	0°C
Next 2 weeks	5°C	5°C	0°C	+10°C	Next week	8°C	8°C	+ 6°C	0°C
Thereafter	6°C	6°C	+9°C	+ 4°C	Next 5 weeks	5°C	5°C	+ 8°C	0°C
					Thereafter	3°C	3°C	+10°C	0°C
2. high:					2. high:				
First 3 weeks	10°C	15°C	0°C	+10°C	First 2 weeks	10°C	15°C	0°C	+10°C
Next 3 weeks	8°C	10°C	0°C	+10°C	Next 5 weeks	8°C	10°C	0°C	+10°C
Thereafter	6°C	9°C	0°C	+10°C	Thereafter	6°C	9°C	0°C	+ 4°C

* Ventilators open the first week 30 p.c., next two weeks 50 p.c. and next two weeks 40 p.c.

Table 2. Pakchoy. Treatments in 1985.
Forsøgsbehandlinger i 1985.

Variety	'Hypro'
Transplant age	1. 4 week 2. 5 week
Plant spacing	1. 20×25 cm 2. 25×25 cm
Soil heating	1. No soil heating 2. 1st week 20°C then 14°C

Temperature regime		Min. night	Min. day	Light addition	Venti-lation
	1. low*:	5°C	5°C	+5°C	+10°C
	2. High				
	First 3 weeks	10°C	15°C	0°C	+10°C
	Thereafter	8°C	12°C	0°C	+10°C

* Ventilators open 30 p.c. at outdoor temperature above 5°C.

Table 3. Dates for sowing, planting and harvesting 1984 and 1985.
Dato for såning, plantning og høst, 1984 og 1985.

Year	Crop	Sowing dates	Planting date	Harvest dates
1984	1	20/8 and 27/8	17/9	25/10 and 1/11
1984	2	8/10	13/11	11/2 1985
1985		9/9 and 16/9	10/10	27/11

Harvest

In 1984 plants from the first crop were harvested when they weighed about 300 g. The plants were harvested on two days, 25 October and 11 November according to size.

Harvesting of the second crop was enforced on 11 February 1985 due to space demand, even though the weight of the plants was too low.

In 1985 all plants were harvested on 27 November, when most of the plants weighed minimum 300 g.

The most common reason for a plant being classified as unmarketable was a too low weight (below 200 g).

Results

Varieties

In 1984 two varieties of pakchoy were grown, 'Japro' ('RS2701') and 'AH 1005'. There was no difference between the varieties.

Transplant size

In the first crop in 1984 and in 1985 two ages of transplants were compared. In 1984 three weeks old plants had four leaves and were about 13 cm high, while four weeks old plants had five leaves and were approximately 18 cm high. In 1985 four weeks old plants had 4–5 leaves and were 11–14 cm high. Five weeks old plants had 5–6 leaves and were 17–20 cm high with thick white leaf stalks.

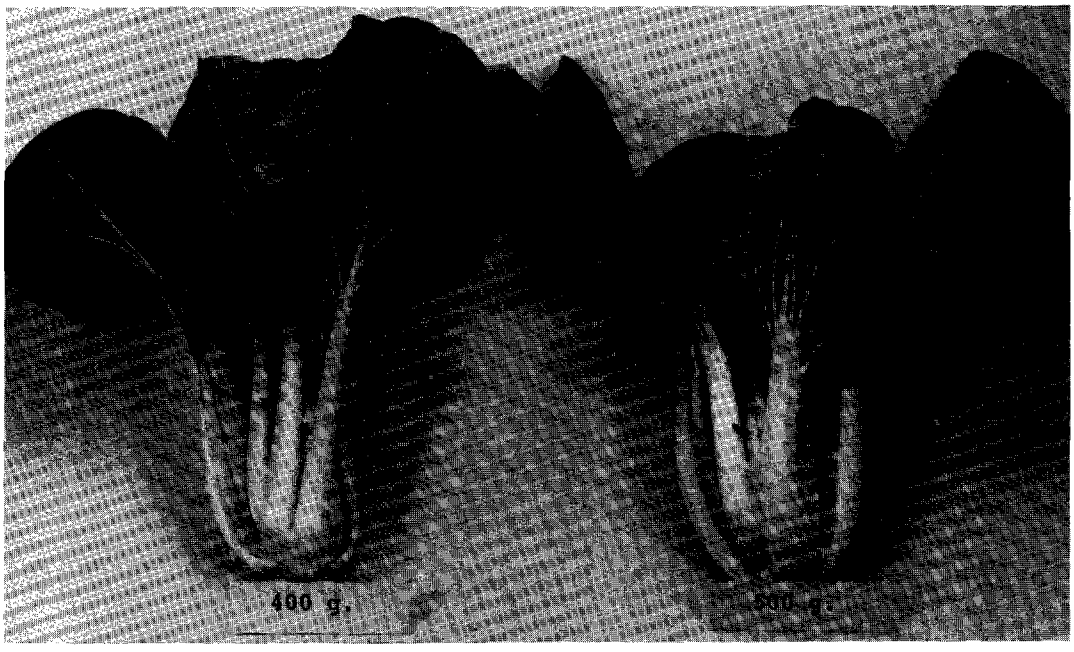

Fig. 1. Pakchoy. Marketable plants of 400 and 500 g.
Salgsklare planter på 400 og 500 g.

Table 4. The influence of transplant age on earliness, total weight per replicate, average weight per marketable plant and per cent marketable plants. 1984, Crop 1.
Udplantningstidspunktets indflydelse på tidlighed, total vægt pr. parcel, vægt pr. plante og procent salgbare planter, 1984.

Transplant age	% harvested at 1. harvest	Weight per 24 plants, kg (Before trimming)	Weight per plant, g (After trimming)	% marketable plants
3 weeks	50*	5,94*	280***	72
4 weeks	66*	6,42*	317***	70

*, *** Treatments are significantly different at P = 0,05 and P = 0,001 respectively.

In 1984 four weeks old transplants were earlier than three weeks old, as a greater number of the oldest plants were harvested at the first harvest (Table 4).

The total weight per replicate (24 plants) and the weight per marketable plant increased with increasing age of transplants (Table 4 and 6) in both years.

In 1984 there was no difference in per cent marketable plants between the two transplant ages. In 1985 there was interaction between climate and age of the transplants. Low air temperature and late sowing gave a significantly lower percentage of marketable plants (Table 5).

Table 5. The influence of transplant age and temperature regime on per cent marketable plants, 1985.
Udplantningstidspunktets og temperaturens indflydelse på procent salgbare planter, 1985.

Temperature regime	Transplant age	
	4 weeks	5 weeks
Low	59*	72
High	71	70

* See Table 4.

In 1985 the youngest transplants had less rot at the time of harvest and they were more compact (Table 6).

Both in 1984 and in 1985 the youngest transplants required less trimming at harvest. The difference was statistically significant in both years.

Plant spacing

In 1984 and in 1985 spacing was either 20 × 25 cm or 25 × 25 cm. In 1984 plants were harvested earlier at the widest spacing (Table 7).

The weight per plant was greatest at the widest spacing in both years (Table 8).

In both the first crop in 1984 and in the 1985 crop the widest spacing produced the highest percentage of marketable plants.

Yield in kg per m^2, calculated by means of spacing, per cent marketable plants and plant weight, is higher at the greatest spacing in 1984, but about the same in 1985.

Temperature regime

Pakchoy was grown at two different temperature regimes (Table 1 and 2). The low temperature regime is that normally used for a lettuce crop in the autumn.

Table 6. The influence of transplant age on total weight per replicate, average weight per marketable plant, per cent plants with rot, and compactness of the plant (1–9, 9 = most compact), 1985.
Udplantningstidspunktets indflydelse på total høst pr. parcel, vægt pr. plante, procent planter med råd og planternes kompakthed (1–9, 9 = mest kompakt), 1985.

Transplant age	Weight per 24 plants, kg (Before trimming)	Weight per plant, g (After trimming)	% plants with rot	Compactness
4 weeks	6,92***	318***	1,7*	5,04*
5 weeks	8,29***	360***	4,3*	4,94*

*, *** See Table 4.

Table 7. The effect of plant spacing on earliness. 1984, Crop 1.
Indflydelse af planteafstand på tidlighed, 1984.

Plant space	% harvested at 1st harvest
20 × 25 cm	52*
25 × 25 cm	57*

* See Table 4.

The average weight per plant was greatest at the highest temperature regime especially in the second crop in 1984 and in the 1985 crop (Table 9). The increase in weight in the first and second crop in 1984, and in the 1985 crop was 5, 21 and 11% respectively. The difference in weight between temperatures was statistically significant only in the second crop in 1984.

In the 1985 crop more marketable plants were harvested at the high temperature, but the difference was not statistically significant. In both crops in 1984 there was no difference.

Soil heating

In 1984 the minimum temperature in the unheated soil was 10–11°C at the time of planting. During the next two months the temperature dropped to 6–7°C. The minimum temperature in the heated soil was 11–14°C.

In 1985 the minimum temperature in the unheated soil was 11–12°C at the time of planting. After one week the temperature dropped to 9–11°C and was then constant. In the last one and a half month the soil temperature was 1–2°C lower in the cells with low air temperature. Minimum soil temperature in the heated soil was 18–20°C the first week. During the next month it dropped to 13–15°C and was then constant.

In 1984 soil heating significantly increased the weight per plant (Table 10). The effect was greatest at low air temperature.

In 1985 there was no statistically significant effect of soil heating, although there was a tendency to greater weight when the soil was heated in compartments with low air temperature. Here the difference in temperature between heated and unheated soil was greatest.

Table 8. The effect of plant spacing on per cent marketable plant and average weight per marketable plant, 1984 and 1985.
Planteafstandens indflydelse på procent salgbare planter og vægt pr. plante, 1984 og 1985.

Plant space	Weight per plant, g			% marketable plants	
	1984 Crop 1	1984 Crop 2	1985	1984 Crop 2	1985
20 × 25 cm	277***	155***	330*	60***	63**
25 × 25 cm	292***	180***	349*	75***	73**

*, ***: See Table 4.
**: Treatments are significantly different at P = 0,01.

Table 9. The effect of temperature regime on weight per marketable plant and per cent marketable plants, 1984 and 1985.
Temperaturens indflydelse på procent salgbare planter og vægt pr. plante.

Temperature regime	Weight per plant, g			% marketable plants	
	1984 Crop 1	1984 Crop 2	1985	1984 Crop 1	1985
Low	278	151*	322	68	66
High	292	183*	356	67	71

* See Table 4.

Table 10. The effect of soil heating and temperature regime on weight per marketable plant, 1984 and 1985.
Betydningen af jordvarme og lufttemperatur på plantevægten.

Temperature regime	Soil heating	Weight per plant, g	
		1984 Crop 2	1985
Low	+	177	330
	–	140	316
High	+	203	352
	–	178	360
LSD		14	n.s.

Table 11. The influence of growing media on average weight per marketable plant and on per cent marketable plants 1984.
Betydning af dyrkningssubstratet for vægt pr. plante og procent salgbare planter.

Growing media	Weight per plant, g		% marketable plants
	1984 Crop 1	1984 Crop 2	1984 Crop 1
Soil	280*	159**	72**
Rockwool	258*	153**	61**

*, ** See Table 8.

Soil heating did not affect the per cent of marketable plants or plant quality.

Substrates

In 1984 the plants were grown either in soil or in rockwool. In both crops plant weight was greater when grown in soil, although the difference was very small in the second crop (Table 11).

The per cent of marketable plants was higher from soil grown plants in the first crop. Plants grown in soil had broader and longer leaves.

Discussion and conclusion

Varieties

The two varieties 'AH-1005' and 'Japro' showed no difference in appearance and uniformity.

Neither of the varieties were susceptible to bolting. In Holland 'Japro' (RS 2701) was the best variety compared to several other varieties. 'Japro' proved to be least susceptible to bolting (5). The more recently introduced F1 hybrid 'Hypro' is claimed to be even less susceptible to bolting and more uniform than 'Japro' (2).

Transplant size

The total yield was increased by lengthening the propagation period and thus transplant size. Thereby it was possible to make the cultivation period after transplanting shorter.

In Holland the propagation period is 2–4 weeks if sowing in August or September (2).

Although the yield and earliness were enhanced by planting 5 weeks old plants, it must be considered that the size of these plants makes them difficult to handle during transplanting because they tangle together and are easily damaged. It is possible to use a lettuce planting machine for pakchoy but only for small plants. Depending on the growers' transplanting practice the propagation period in August–September should therefore be four weeks (4–5 true leaves) or five weeks (5–6 true leaves).

Plant spacing

Two plant spacings on respectively 20 × 25 (20 plants per m^2) and 25 × 25 cm (16 plants per m^2) were compared.

Earliness, yield, average weight per plant and per cent marketable plants were enhanced at the wide spacing. Because of greater weight and a higher percentage of marketable plants the yield in kg per m^2 was better in 1984 with fewer plants per m^2. In 1985 the yield in kg per m^2 was the same at the two plant spacings.

The results from a Dutch experiment with five different plant densities ranging from 12–25 plants per m^2 showed that the production per m^2 increased by increasing plant density. Considering plant weight, uniformity and plant costs a plant density of 18 plants per m^2 was recommended. Sowing was late August (6).

In another Dutch experiment with pakchoy sown on 26 November six different plant densities from 14.8 to 30.3 plants per m^2 were compared. The conclusion was that for a spring crop a plant density of 22–24 plants per m^2 was best (7).

Considering the results presented here and the Dutch experiments, 16–18 plants per m^2 appears optimum for an autumn/winter crop of pakchoy in Denmark.

Temperature regime

Two different temperature regimes were tested for two years (see Table 1 and 2).

There was a tendency towards greater plant weight at higher temperatures particularly in the late planting.

In 1985 CO_2 was supplied when the windows were closed, and since there was less ventilation at the higher temperature regime more CO_2 was supplied. This may also contribute to the weight increase.

The experiments showed that it is possible to grow pakchoy at low temperatures that is 5°C at night and 5–10°C during the day dependent on the light. By raising the temperature it is possible to shorten the growing period.

In Holland it is recommended to grow pakchoy by the same temperature regime as lettuce, that is 5°C at night and 10°C during the day (1,2).

Soil heating

In the second crop in 1984 and in the 1985 crop soil heating was supplied to half of the plants.

Plant weight was increased by soil heating. The effect was greatest at low air temperature. In 1984 soil heating and low air temperature gave the same yield as high air temperature and no soil heating. That means that soil heating can compensate for low air temperature. In 1985 soil temperature without soil heating was higher than in 1984 and the effect was therefore smaller.

There are no reports in the literature on soil heating for pakchoy. Lettuce grown in nutrient film at 14°C gave a higher weight per head than 7°C, and 16°C gave a higher weight than 12°C (3). The yield per m^2 was greater with soil heating in endive (4).

Substrates

Soil and rockwool mats were compared as a growing medium.

Plants grown on soil were earlier, larger and provided a higher percentage of marketable plants. The reason for the lower yield on rockwool could be that the root volume was smaller and that the mats collapsed during the crop.

Though yield was lower on the thin rockwool mats it is possible for growers who normally use rockwool for other crops and do not want to use their soil for growing, to use these and other rockwool mats for pakchoy.

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