

## Effects of seed rate, plastic covering, and harvest time on yield and quality of Danish grown basil (*Ocimum basilicum* L.)

*Betydningen af udsædsmængde, plasticdækning og høsttidspunkt for udbytte og kvalitet i basilikum (Ocimum basilicum L.)*

LIS SØRENSEN & KAJ HENRIKSEN

### Summary

Improved cultivation of basil (*Ocimum basilicum* L.) under Danish growth conditions was investigated by evaluating the effects of seed rate and use of covering during establishment in field trials. The effect on number of plants established was included in 1991. In 1989, basil was grown at 2 seed rates (4 and 6 kg/ha) and in 1991, at 3 seed rates (4, 6 and 10 kg/ha), both years half of the plots was covered 4-5 weeks from sowing. The climatical conditions had great influence on the results. In 1989 low yield levels were found; maximum yield of leaves was 8.6 tons/ha at

6 kg seed/ha in contrary to 1991 which at the same seed rate yielded 12.8 tons/ha.

After covering in 1991, many plants established and the number of plants increased when seed rate was increased. Grown without covering less plants established and the number of plants increased only slightly with increasing seed rate.

Increasing seed rate tended to increase the yield of leaves. The increase was significant in covered basil 1991 when harvested early. Covering reduced the growing period by almost one third (20-25 days).

**Key words:** Basil, *Ocimum basilicum* L., seed rate, plastic covering, harvest time, plant establishment, growing period, yield.

### Resumé

Muligheden for at forbedre dyrkningsikkerheden af basilikum (*Ocimum basilicum* L.) under danske forhold er blevet prøvet i forsøg. Betydningen af udsædsmængde og dækning under etablering på totaludbytte og udbytte af tærskede blade blev undersøgt i 1989 og 1991. I 1991 blev også effekten på etablerede planter undersøgt. I 1989 blev ud-

sædsmængderne 4 og 6 kg/ha afprøvet, i 1991 desuden 10 kg/ha. Resultaterne viste sig at være meget årsafhængige, i 1989 var udbytteerne lave, højeste udbytte af tærskede blade var 8,6 tons/ha (6 kg frø/ha), i 1991 gav samme frøsmængde op til 12,8 tons/ha.

Dækning med fiberdug i 1991 gav flest planter og stigende planteantal, når udsædsmængden blev

øget. Uden dækning etablerede færre planter sig, og antallet steg svagere ved øget udsædsmængde.

Ved stigende udsædsmængde fandtes en tendens til stigende udbytte af tærskede blade. Stigningen var signifikant i basilikum, som var dækket under

etableringen og høstet tidligt i 1991. Ved dækning var det muligt at høste tidligere i 1991. Den samlede vækstperiode blev forkortet med omtrent en trediedel (20-25 dage) sammenlignet med udækket etablering.

**Nøgleord:** Basillikum, *Ocimum basilicum* L., udsædsmængde, plastikdækning, høsttidspunkt, planteetablering, vækstperiode, udbytte.

## Introduction

Basil (*Ocimum basilicum* L.) is an annual plant of the *Labiaceae* family native to Asia (1). The plant is grown for fresh use, freeze drying or production of essential oil. Cultivation of basil for industrial purposes has ceased in Denmark due to the risk of poor plant establishment, low yields and low quality of the product. As basil is very sensitive to weather conditions, adverse climatic conditions are the main obstacle for successful cultivation. Basil demands high temperatures because of its 'South Asian' origin. Many herbs grown in Denmark are of Mediterranean origin and can be grown at lower temperatures than basil. Furthermore, commercial cultivation under Danish conditions has shown that basil is very sensitive to wind which causes damages to the leaves resulting in dry, brown areas or fungal infections. Investigations from Finland (2) showed that covering during the growth period increased yield 3 fold compared to uncovered.

The present experiments were carried out to investigate the possibility to improve cultivation of basil under Danish conditions by evaluating the effects of seed rate, use of cover material during plant establishment and harvest time on plant number, yield and quality of basil (*Ocimum basilicum* L.).

## Materials and methods

In field experiments basil (*Ocimum basilicum* L.) was grown for freeze drying. The trials were carried out in 1989 and 1991 at the Department of Vegetables, Aarslev, on a sandy loam soil.

**1989.** In 2 separate experiments basil was tested covered or uncovered during plant establishment. In both experiments seed rates of 4 and 6 kg/ha were included. Seeds were sown in the field 1 June with a row distance of 30 cm. In covered plots transparent plastic (0.05 mm thick) with 500 holes/m<sup>2</sup> was

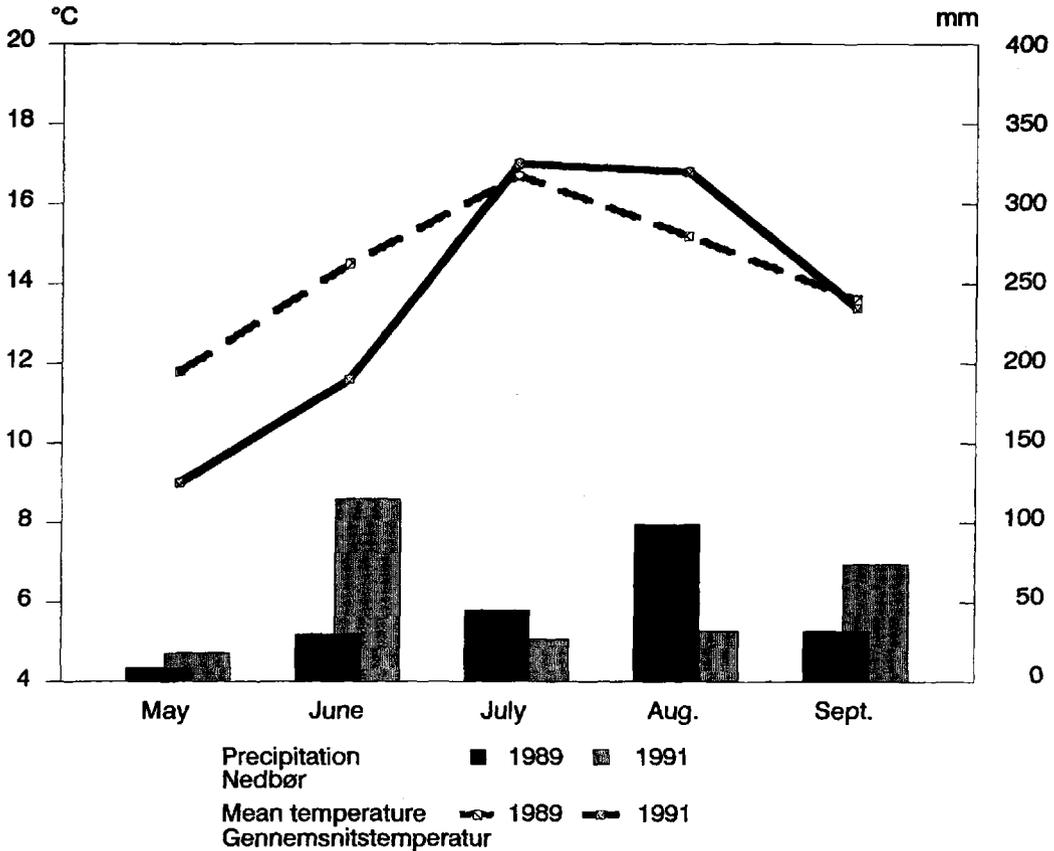
placed immediately after sowing. The cover was removed 34 days later. Preplant fertilizer (40 kg N/ha) was incorporated into the soil before sowing and during growth 40 kg N/ha were applied, the covered experiment further received 48 kg N/ha. Irrigation was done in dry periods. Weeds were controlled by hand weeding. Plot size at harvest was 1.5×1.0 meter. Plants were cut approximately 2-4 cm above the soil. Harvest of covered plots took place 77 days after sowing, uncovered plots were harvested 97 days after sowing.

Total yield of fresh material which included leaves, petioles and stems was determined. The harvested basil was frozen (-18°C) and threshed. Threshing was done by passing the frozen basil through a sieve with 2.7 mm holes. Stem parts were discarded by this process. Yield of leaves passing through the sieve was determined. Yield per ha was calculated on the basis of a bed system with 4 rows spaced 30 cm apart with 60 cm row spacing to the next bed.

**1991.** Basil was grown at seed rates of 4, 6 and 10 kg/ha with or without covering during plant establishment, and with 3 harvest times. Seeds were sown in the field 6 June with a row distance of 30 cm. In the covered areas fiber netting (polypropylene, 17 g/m<sup>2</sup>) was used. The fibre netting was removed 27 days after sowing. Before sowing 52 kg N/ha was incorporated in the soil and subsequent 52 kg N/ha was applied 10 July. Irrigation was done when necessary. Weeds were removed by hand.

Plant stand was counted 45 days after sowing. Covered plots were harvested either 44, 54 or 68 days after sowing, uncovered plots 69, 85 or 93 days after sowing. At harvest the plants were cut 4-6 cm above the soil. Plot size at harvest was 1.5×2.0 meter.

Recordings of total yield of fresh material and threshed leaves were determined as in 1989. For determination of quality a sample from each combi-



**Figure 1.** Monthly climatic records for Aarslev in 1989 and 1991 (4 and 5).  
*Klimadata for Årslev i 1989 og 1991 (4 og 5).*

nation of seed rate, use of cover and harvest time was freeze dried. Freeze drying from  $-32^{\circ}\text{C}$  to  $+20^{\circ}\text{C}$  was performed in a Christ Gamma 1-20 freeze dryer for 24 hours. Surface colour and proportion of stem pieces were recorded visually in the freeze dried product.

The experiment was arranged in a split-plot design with 3 replications, covered versus uncovered being whole-plots, seed rate and harvest time being sub-plots.

Effects were tested by analysis of variance and General Linear Models (GLM) procedure.

### Climatical conditions

Average monthly temperatures and precipitation for 1989 and 1991 are shown in Fig. 1.

In 1989, the experiment was established during

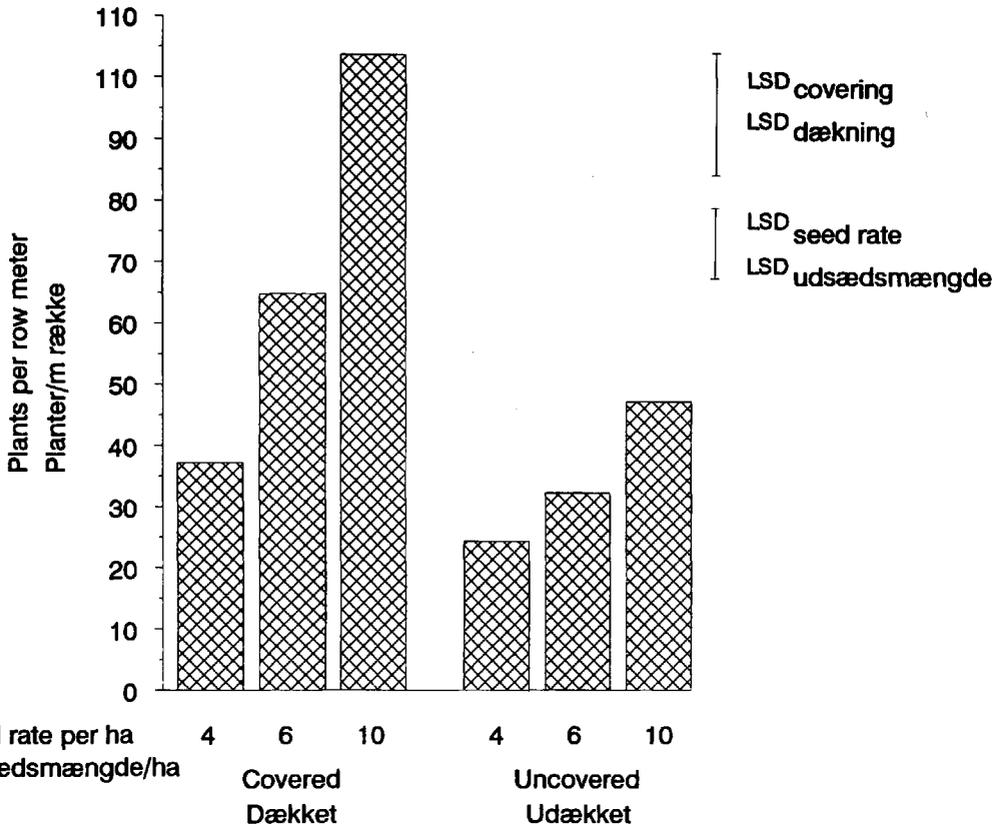
a mild and dry period, whereas 1991 was cool and rainy during establishment. The weather in August was cool and rainy in 1989, when compared to 1991 (4 and 5).

The experiment site was exposed to wind in 1989, whereas it had good shelter from wind in 1991.

### Results

#### 1989

Yield levels were low in both covered and uncovered experiment. Increased seed rate tended to increase the total yield of fresh basil and yield of threshed leaves (Tab. 1 and 2), although no significant difference was found. Yield of leaves was highly correlated to total yield. The uncovered experiment showed a significant lower proportion of leaves at 4 kg/ha than at 6 kg/ha.



**Figure 2.** Effect of seed rate and covering during plant establishment on number of plants in 1991. Vertical bars indicate LSD ( $P = 0.05$ ).

*Effekten af udsædsmængde og dækning under etablering på planteantallet i 1991. Vertikale linier angiver LSD ( $P = 0,05$ ).*

**Table 1.** Total yield of fresh basil, basil leaves and proportion of leaves at 2 seed rates grown with covering during plant establishment in 1989.

*Totaludbytte, bladudbytte og vægtprocent blade af basilikum ved 2 udsædsmængder etableret med plasticdækning i 1989.*

Seed rate <i>Udsæds- mængde</i>	Total yield <i>Totaludbytte</i>	Yield of leaves <i>Bladudbytte</i>	Proportion of leaves <i>Vægtprocent blade</i>
	(t/ha)	(t/ha)	(pct.)
4 kg/ha	5.3	3.2	60.1
6 kg/ha	9.3	5.3	57.0
P-value*	0.135	0.108	0.390

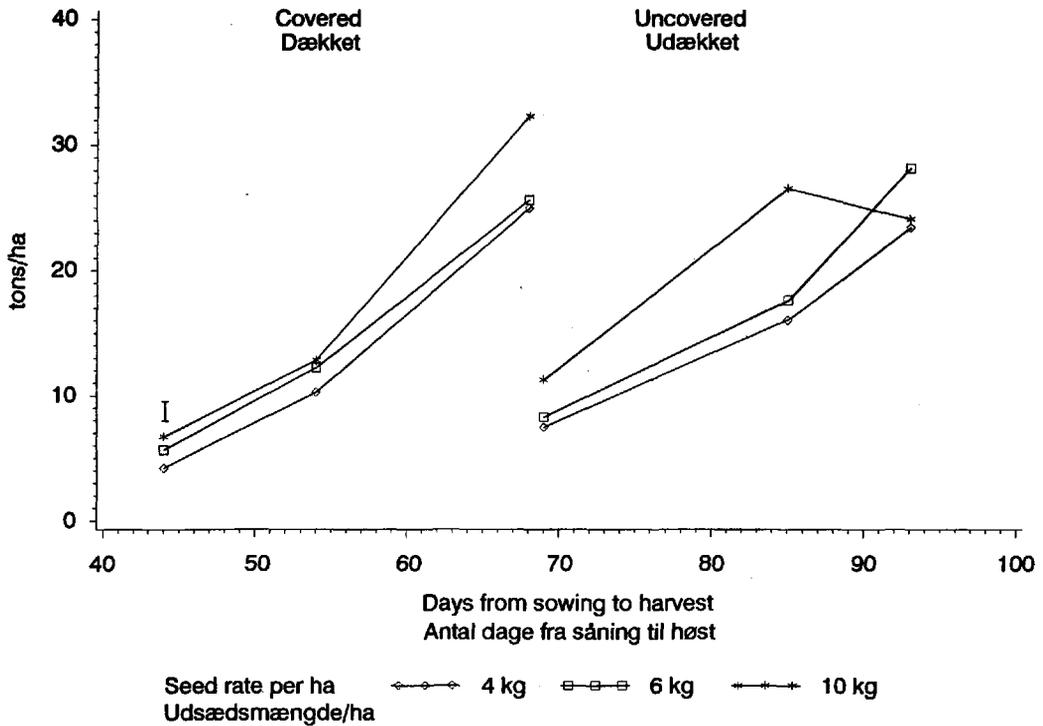
\* Level of significance from the analysis of variance.  
*Signifikansniveau fra variansanalyse.*

**Table 2.** Total yield of fresh basil, basil leaves and proportion of leaves at 2 seed rates grown without covering during plant establishment in 1989.

*Totaludbytte, bladudbytte og vægtprocent blade af basilikum ved 2 udsædsmængder etableret uden plasticdækning i 1989.*

Seed rate <i>Udsæds- mængde</i>	Total yield <i>Totaludbytte</i>	Yield of leaves <i>Bladudbytte</i>	Proportion of leaves <i>Vægtprocent blade</i>
	(t/ha)	(t/ha)	(pct.)
4 kg/ha	12.0	5.7	46.4
6 kg/ha	14.3	8.6	60.2
P-value*	0.350	0.113	0.027

\* Level of significance from the analysis of variance.  
*Signifikansniveau fra variansanalyse.*



**Figure 3.** Effect of seed rate and covering during plant establishment on total yield at 3 harvest dates in 1991. Bar indicates LSD at  $P = 0.05$ . LSDs are only shown when the analysis of variance indicates a statistically significant difference.

*Effekt af udsædsmængde og dækning under etableringen på totaludbytte ved 3 høsttidspunkter i 1991. Vertikal linie angiver LSD ( $P = 0,05$ ). LSD-værdi er kun angivet, hvor variansanalysen viser en statistisk signifikant forskel.*

## 1991

### Seed rate

The number of plants established per row meter increased with increased seed rate (Fig. 2). Covering during establishment gave a stronger increase in plant number at increasing seed rate compared to uncovered.

Increasing seed rate gave no significant increase in total yield, except in basil covered during establishment and harvested 44 days after sowing (Fig. 3). The total yield tended to increase at increasing seed rate with the exception of the seed rate 10 kg/ha established without covering and harvested 93 days after sowing.

The yield of leaves increased significantly in basil covered during establishment and harvested 44 and 54 days after sowing (Fig. 4). At the remaining harvests no significant increase was found.

The proportion of leaves was not affected by seed rate (results not shown).

### Covering

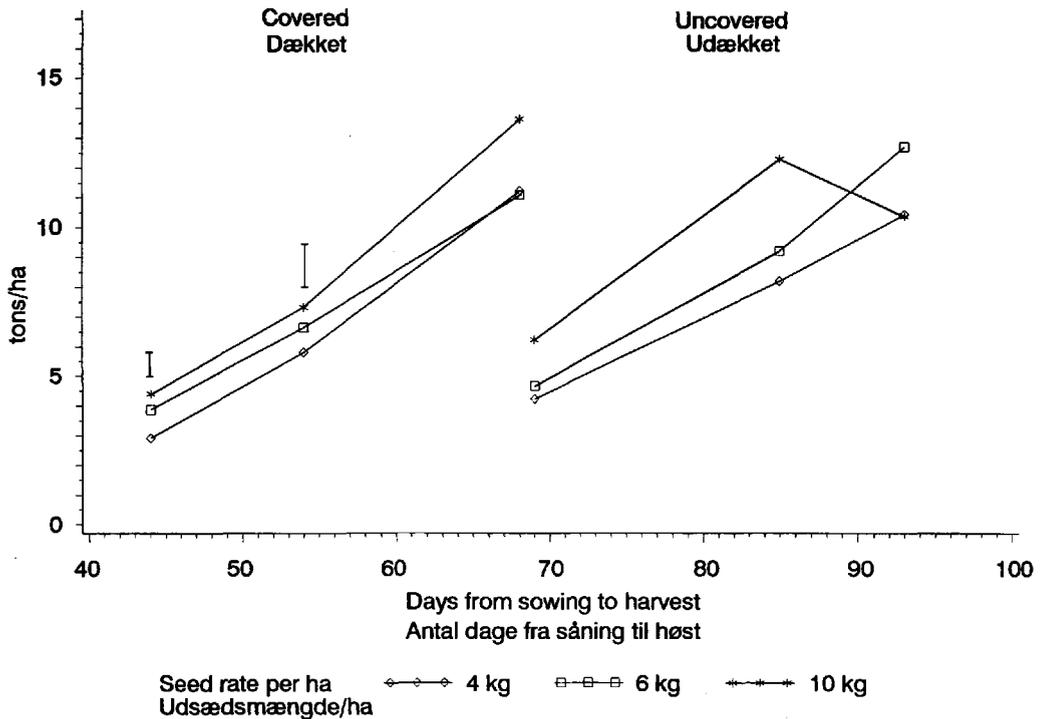
Covering during emergence and early growth increased the number of plants established compared to plants established without cover (Fig. 2). The plant number increased by 54-120 per cent by use of cover, the highest increase was found at a seed rate of 10 kg/ha.

Comparisons of yield levels from covered and uncovered areas were not possible, since harvests were postponed in uncovered areas to get yield levels similar to those of covered areas, and only 3 harvest dates were included. The latest harvest was taken just before onset of flowering in both covered and uncovered areas.

Compared to uncovered areas covering reduced the growing period 20-25 days for equal yield levels.

### Time of harvest

Total yield increased significantly as the growing pe-



**Figure 4.** Effect of seed rate and covering during plant establishment on yield of frozen, threshed leaves at 3 harvest dates in 1991. Bars indicate LSD at  $P = 0.05$ . LSDs are only shown when the analysis of variance indicates a statistically significant difference.

*Effekt af udsædsmængde og dækning under etableringen på bladudbytte ved 3 høsttidspunkter i 1991. Vertikale linier angiver LSD ( $P = 0,05$ ). LSD-værdi er kun angivet, hvor variansanalysen viser en statistisk signifikant forskel.*

riod was prolonged (Fig. 3) whereas the proportion of leaves was significantly reduced as the growing period was prolonged (Fig. 5). The increase in total yield exceeded the decrease in proportion of leaves to the extent that yield of leaves increased significantly as the growing period was prolonged (Fig. 4).

#### Quality after freeze drying

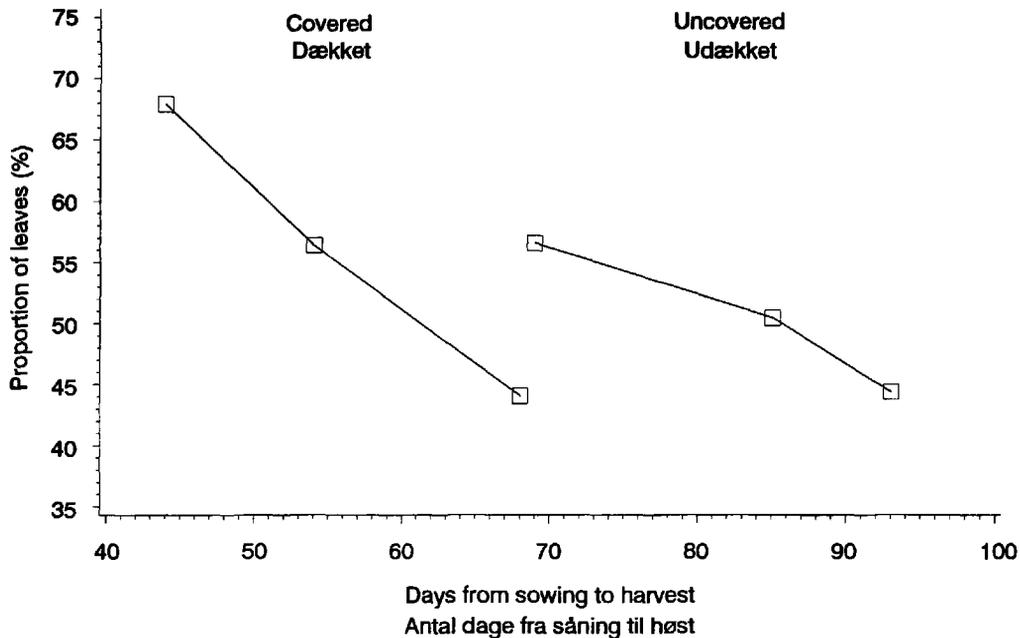
The quality of the freeze dried product was judged visually. The surface colour was greyish green and did not differ due to seed rate, use of cover or harvest time. The content of small stem pieces was low and acceptable for all treatments.

## Discussion

The low yield levels of 1989 was caused by various factors. The weather conditions during germination and emergence of the plants were good. Plants

emerged quickly, after approximately 12 days when covered and 19 days without cover. Further growth took place under adverse conditions, especially in August, which was rainy with heavy showers (up to 51 mm/day) (4) and the experiment had no shelter from wind. The negative effects of covering in 1989 could be due to the cover material used. The translucent plastic would give high soil and air temperatures under the cover during periods with sunny weather. June 1989 had 284 hours of sunshine compared to an average of 265 hours (4). A late removal of the plastic (34 days after sowing) increased the risk of leaves getting scorch damage (3).

In 1991, the experiment was established under cold and rainy conditions (5). This caused a very slow germination of seeds in uncovered areas; after 28 days only few plants had emerged. The rain may have caused development of a crust on the soil in uncovered areas, which could explain the reduced number of plants in those areas. The covered plants



**Figure 5.** Effect of covering during plant establishment on proportion of leaves at 3 harvest dates in 1991. Average of seed rates.

*Effekt af dækning under etableringen på vægtprocent blade på 3 høsttidspunkter i 1991. Gns. af udsædsmængder.*

emerged as early as in 1989. Good protection from wind and warm weather with little rain gave good growth conditions for the remaining period.

Finnish investigations (2) showed a 3 fold increase in yield when cover was used during the total growing period. The Finnish experiments differed from the present in the methods used. *Hälvä* (2) established the experiments by transplants, covering was used during the total growing period which was of equal length irrespective of covering or not. This method would also give great differences in yield levels if adopted to the present experiments, with equal yield levels being obtained 20-25 days earlier when basil was covered compared to uncovered during establishment. In transplanted crops the difference in earliness would be smaller since no time difference in germination effects the experiment. *Hälvä* reported that no difference in growth and development was found between covered and uncovered basil. The climatical conditions in the Nordic countries put limitations to cultivation of basil. Under Mediterranean conditions over 110 t/ha of fresh basil was reported from 5 repeated harvests over a 6 month period (6).

In the present experiment the total growing period was reduced by close to one third when covered during establishment. Covering shortened the time the crop was uncovered to nearly half of the growing period, reducing the risk of adverse weather conditions which easily decrease yield and quality or deteriorate the crop.

Further investigations into the effects of climatical conditions and wind on plant establishment, growth, yield and quality will be needed to fully evaluate the possibilities to improve cultivation of basil (*Ocimum basilicum* L.) under Danish conditions.

### Acknowledgement

The experiment was part of the project "Introduction of new vegetables" supported by the Joint Committee for Agricultural Research and Experiments. In 1989, the experiment was carried out by *Birte Boelt*. Appreciation is expressed to *Kristian Kristensen*, Department of Biometry and Informatics for statistical advice.

## References

1. *Encke, F.* (ed.) *Pareys Blumengärtnerrei*. Paul Parey, Berlin und Hamburg 1960, II pp. 480.
2. *Hälvä, S.* 1987. Studies on production techniques of some herb plants. I Effect of Agryl P17 mulching on herb yield and volatile oils of basil (*Ocimum basilikum* L.) and marjoram (*Origanum majorana* L.). *Journal of Agri. Science in Finland* 59, 31-36.
3. *Henriksen, K.* 1985. Plastdækning af såede grønsager. *Statens Planteavlsvorsøg. Meddelelse. nr. 1827.*
4. *Olesen, J.E.* 1990. Jordbrugsmeteorologisk årsoversigt 1989. *Statens Planteavlsvorsøg. Beretning nr. S 2055.*
5. *Olesen, J.E.* 1992. Jordbrugsmeteorologisk årsoversigt 1991. *Statens Planteavlsvorsøg. Beretning nr. S 2202.*
6. *Putievsky, E. & Basker, D.* 1977. Experimental cultivation of marjoram, oregano and basil. *Jour. Hort. Sci.* 52, 181-188.

Manuscript received 23 December 1992