

Yield, plant growth and quality of vining pea varieties at early and late sowing dates

Udbytte, plantevækst og kvalitet af ærtesorter til dybfrost ved tidlig og sen såning

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Summary

Experiments with 11 varieties of vining peas (*Pisum sativum* L. *convar medulare* Alef.) planted at early and late sowing dates were made in 1989 and 1990 to determine the yield, pea size distribution, plant growth and quality for deep freezing. The earliness of the varieties was determined as temperature sums with base temperature 4.5°C from sowing to harvest at tenderometer readings (TR) 110. The early variety 'Avola' and the late variety 'Turon' were used as standards.

Statistical analysis showed highly significant differences between varieties, and highly significant interaction between year and variety. The varieties 'Karisma' and 'Solist' showed high yields of 6 to 9 t/ha in both years. The varieties 'Marinka' and 'Dewdrop' had low yields of 2 to 5 t/ha in both years. Early sowing date did not in general produce the highest yields of peas compared to a late sowing date. The varieties 'Sunroy', 'Chico' and 'Dewdrop' showed higher yields at late sowing than at early sowing.

The size grading of the peas allowed the 11 varieties to be divided into 3 groups. 'Avola', 'Solist' and 'Karisma' had more than 80% of the peas larger than 8.75 mm in diameter. 'Ator', 'Sunroy',

'Chico' and 'Turon' had between 55% and 65% larger than 8.75 mm and 'Dewdrop', 'Cobalt', 'Marinka' and 'Lambado' had less than 45% larger than 8.75 mm.

The results of a visual quality evaluation showed the highest scores for dark green colour in the varieties 'Marinka', 'Solist' and 'Dewdrop'. The varieties 'Sunroy' and 'Ator' had a good green colour whereas 'Avola', 'Cobalt', 'Lambado' and 'Chico' were light green with many pale peas.

The amount of alcohol insoluble solids (AIS) was highly correlated with the TR of the varieties and 92% of the variation in the data could be explained by a linear relationship between AIS and TR in the varieties ($R^2 = 0.92$). There were significant differences between the varieties. 'Solist' and 'Karisma' showed high AIS values in relation to TR, whereas 'Lambado', 'Avola', and 'Sunroy' had low values. High AIS value in relation to TR is an indication of poor organoleptic quality.

The temperature sum with base temperature 4.5°C from sowing to harvest was found to be a rather variable measure of the earliness of a variety. The temperature sum > 4.5°C value of a certain variety showed variation of up to 20% between years and

between sowing dates depending on the actual weather in the growth period. For planning purposes and to predict the harvest date reliably a more

detailed model describing the growth of pea plants in relation to weather and other growing conditions is needed.

Key words: Vining pea, *Pisum sativum* L. *convar medulare* Alef., variety, deep freezing, sowing date, yield, plant growth, temperature sum, colour, alcohol insoluble solids, AIS.

Resumé

I årene 1989 og 1990 blev 11 sorter af lave marvæfter dyrket på sandblandet lerjord for at undersøge udbytte, størrelsesfordeling, plantevækst og kvalitet ved tidlig og sen såning. Tidligheden af sorterne blev bestemt som temperatursummen med basis 4,5°C fra såning til høst ved tenderometerværdi (TR) 110. Den tidlige sort 'Avola' og den sene sort 'Turon' blev anvendt som målesorter.

Statistiske analyser viste signifikante forskelle mellem sorter og signifikant vekselvirkning mellem år og sort. Det aktuelle vejrlig i vækstperioden var mere afgørende for udviklingen og udbyttet end såtidspunktet. Sorterne 'Karisma' og 'Solist' viste høje udbytter fra 6 til 9 t/ha i begge år. Sorterne 'Marinka' og 'Dewdrop' viste lave udbytter fra 2 til 5 t/ha. Tidlig såning gav ikke generelt højere udbytter i grønne ærter end sen såning. Sorterne 'Sunroy', 'Chico' og 'Dewdrop' havde højere udbytter ved sen såning end ved tidlig såning.

Størrelsessorteringen delte sorterne i 3 grupper. 'Avola', 'Solist' og 'Karisma' havde over 80% af ærterne større end 8,75 mm i diameter. Sorterne 'Ator', 'Sunroy', 'Chico' og 'Turon' havde mellem 55% og 65% større end 8,75 mm og sorterne 'Dewdrop', 'Cobalt', 'Marinka' og 'Lambado' havde under 45% større end 8,75 mm.

Den visuelle bedømmelse af farven på ærterne viste, at sorterne 'Marinka', 'Solist' og 'Dewdrop' var de mest mørkegrønne. 'Sunroy' og 'Ator' fik også god karakter for farve, mens 'Avola', 'Cobalt', 'Lambado' og 'Chico' var lyse og indeholdt mange 'gule' ærter.

Indholdet af alkohol-uopløseligt tørstof (AIS) var stærkt korreleret med TR inden for sorten, og 92% af variationen ($R^2 = 0,92$) i datamaterialet kunne forklares ved en lineær sammenhæng. Der var signifikante forskelle mellem sorterne, og 'Solist' og 'Karisma' viste høje AIS-værdier i forhold til TR, medens 'Lambado', 'Avola' og 'Sunroy' havde lave værdier. Høj AIS-værdi i forhold til TR indikerer problemer med kvaliteten i form af melet smag.

Temperatursummen med en basistemperatur på 4,5°C fra såning til høst for en sort var ikke en fast størrelse, men kun et relativt mål for, hvor hurtigt ærtesorten udvikler sig. Temperatursummens størrelse varierede med op til 20% mellem år og mellem såtider afhængig af det aktuelle vejr i vækstperioden. Til at planlægge og forudsige høsttidspunktet er der brug for en model, der beskriver væksten af ærteplanten i forhold til vejrlig og øvrige dyrkningsfaktorer mere detaljeret.

Nøgleord: Ærter, marvæfter, *Pisum sativum* L. *convar medulare* Alef., sorter, dybfrost, konserves, såtidspunkt, udbytte, plantevækst, temperatursum, farve, alkohol-uopløseligt tørstof, AIS.

Introduction

Peas (*Pisum sativum* L. *convar. medulare* Alef.) for deep freezing is an important vegetable crop in Denmark. The total area of vining peas covers around 8,000 ha. The total production per year is about 30,000 tonnes of frozen product of which about 80% is exported. Only the wrinkled seeded sweet type of vining peas are used for freezing in Denmark, and at present there is no production of canned peas. In Denmark sowing of peas starts at the end of March and goes on until the middle of June. The harvest period starts at the end of June and lasts until the beginning of September. The vining pea production is all on contract and the freezing industry uses a temperature sum (heat unit) system (7, 15) to programme the sowing and harvest sequences.

The vegetable freezing industry is constantly looking for new pea varieties to improve product quality, to extend the growing season, and to obtain a more continuous supply to the processing factory. Vining pea varieties have been tested at the Department of Vegetables, Aarslev in cooperation with the processing industry for several years in Denmark (3, 4, 5, 9, 10, 11, 14).

An early sowing date has previously been found to be an important factor for higher yields in both vining peas (16) and dry harvested peas (2, 19, 22).

The objective of this experiment was to test new varieties of vining peas for yield, size distribution, plant growth and freezing quality at early and late sowing dates. Further to determine the 'thermal time' from sowing to harvest at tenderometer readings 110 expressed as a temperature sum with a base temperature of 4.5°C.

Material and methods

Plant material

11 pea varieties were tested in field trials in 1989 and 1990. The choice of varieties for these trials were towards a) early maturing, b) high yield and c) smaller sieve size. The pea varieties tested are listed in Table 1. 'Avola' and 'Turon' were used as standard varieties at both sowing dates.

Design of the experiment

The field trial was designed as a complete block design with 4 replicates, and the early and late sown plots were placed in neighbouring areas in the field. 2 additional plots were used for botanical samples and pretesting for rise in tenderometer read-

ings. Harvest area in each plot was 13.5 m² and row spacing was 12 cm. The plant density was planned to be 100 plants per m² in the early sowing and 90 plants per m² in the late sowing. The soil at the research centre is a sandy loam, and the plots were only irrigated in the case of severe drought.

The soil was applied 50 kg P/ha and 200 kg K/ha before drilling. Weeds were controlled with dinoseb (Premilan), when the peas were about 5 cm high. Pests were controlled with synthetic pyrethroids if necessary. There were no fungicide spraying, but the seeds were dressed with metalaxyl (Apron).

The early sowing dates were 13 April and 11 April in 1989 and 1990 respectively. The late sowing dates were 22 May and 30 May in 1989 and 1990 respectively.

Plant growth

The date of emergence, beginning of flowering, and end of flowering were recorded. Date of emergence was defined as the date when 50% of the plants were clearly visible. Date of flowering was defined as the date when 50% of the plants had open flowers. End of flowering was defined as the date when less than 5% of the plants had open flowers.

Plant development registrations were made from random samples of 10 plants at harvest. Haulm length from the first node to the top was measured. First node was defined as the first rudimentary leaf over the seed (under ground hypocotyl node). The number of nodes to the first pod, the number of nodes with pods and the total number of pods were counted. The number of pods per node was calculated. The curving of the pods and the shape of the pod end (pointed or blunt) was recorded.

Tenderometer readings

Samples of about 3 m² were harvested by hand every 2nd or 3rd day when the peas had reached tenderometer readings (TR) of about 80, and until the TR was about 130. The samples were threshed and the TR was measured in a 'Martin Pea Tenderometer' (type FMC/IMC. 384). The TR were used to point out the date for harvest and to record the rate of maturation of the different pea varieties. The temperature sums > 4.5°C from sowing until TR 110 were calculated by means of these samples and the average daily air temperature.

Harvest

4 replicated plots were harvested as close to TR 110 as possible. The plant material was cut off about 5

Table 1. Vining pea varieties tested in 1989 and 1990 and the supplier of seeds. Variety names in brackets are synonyms or preliminary names.

Sorter af lave marvævter i forsøgene i år 1989 og 1990, samt navn og adresse på de frøfirmaer, der har leveret frø af sorterne. Sortsnavnene i parentes er synonymmer.

Variety name	Seed company	Address
'Avola' ('Spring')	Asgrow	Asgrow Seed Company, 7000 Portage Road, Kalamazoo MI 49001. USA.
'Cobalt'	Clause	Société Clause Compatabilité, 1 Avenue Lucien Clause, 91220 Bretigny Cedex. France.
'Lambado' ('Salvado')	S&G	Sluis & Groot BV, P.O. Box 13, Enkhuizen. The Netherlands.
'Marinka'	Agri	Agri Saaten Gmbh, Siemensstrasse 43, D-2084 Rellingen, Postfach 1151. Germany.
'Solist' ('Wav F 504')	v. Wav	van Waveren Planzenzucht Gmbh, D-3405 Rosdorf Über Göttingen. Germany.
'Sunroy'	R.S.	Royal Sluis, Postbus 22, 1600 Enkhuizen. The Netherlands.
'Chico' ('Rico')	Schäfer	Schäfer Seed Co., P.O.Box 3437, D-3400 Göttingen. Germany.
'Ator'*)	Sperli	Carl Sperling & Co., Hamburger Strasse 27, D-2120 Lüneburg, Postfach 2640. Germany.
'Dewdrop'*) ('HP 147-7')	Rog. Br.	Rogers Brothers Seed Co., P.O. Box 4727, Boise ID 83711-0727. USA.
'Karisma'*) ('XPF 214')	Asgrow	(see above)
'Turon' ('Evy')	Asgrow	(see above)

*) semi leafless type.

('Karisma' is not yet approved by the EEC Common Catalogue but protected in the UK).

cm above ground level and threshed in a 'mini-viner' (Schepers techniek bv, Hoogeveen, Holland). The total fresh weight of plant material, and the fresh weight of shelled and cleaned peas were recorded. The peas were washed in a rotating drum with 6.0 mm round holes. The TR of the ungraded peas was measured for each plot.

The yield of shelled peas was adjusted to TR 110 using a yield-TR relationship developed in earlier work (9). (The yield-TR relationship is also used by the Danish industries to convert yield at the various farms to the same developmental stage). Hereafter the replicates were combined two by two

and treated as 2 replicates for further analysis. The peas were size graded in a 2.5 m long rotating drum with 4 sections of round holes. The diameters of the holes were 7.5, 8.2, 8.75, and 10.2 mm respectively. The weight percentage and TR of each fraction were recorded. To indicate the size of the peas for each variety a 'DK-sieve-size' value was calculated as the sum of the weight per cent value of each grading multiplied by the lower range value in mm of the fraction. The DK-sieve-size for each variety thereby indicates a weighed average of the pea size.

3 samples of 500 g from each grading were

Table 2. Monthly climatic records for Aarslev in 1989 and 1990 compared to a 30 year average. *Klimadata for Årslev i årene 1989 og 1990 sammenholdt med et 30 års gennemsnit.*

Month	Mean temperature, °C <i>Gennemsnitstemperatur °C</i>			Precipitation, mm <i>Nedbør, mm</i>		
	1989	1990	Average 1961-90	1989	1990	Average 1961-90
April	5.9	7.3	5.9	35	29	37
May	11.8	12.6	11.0	9	4	46
June	14.5	14.3	14.5	30	113	53
July	16.7	15.4	15.8	45	46	61
August	15.2	16.9	15.8	99	67	59
September	13.6	11.7	12.8	32	111	57

Month	Solar radiation, MJ/m ² <i>Indstråling MJ/m²</i>			Hours of sunshine, h <i>Solskinstimer</i>		
	1989	1990	Average 1961-90	1989	1990	Average 1961-90
April	370	467	384	174	221	169
May	633	670	549	329	309	233
June	614	504	580	284	164	238
July	546	625	546	249	267	224
August	409	509	473	190	241	216
September	290	280	297	170	130	150

blanched for 2 minutes at 90°C, cooled rapidly and packed in plastic bags before storage at -24°C until analyses and organoleptic evaluation.

Quality evaluation

The blanched samples of each combination of variety and sowing date were visually evaluated in a session with representatives from the processing industry and the Department of Food Science and Technology, Aarslev. The pea samples were evaluated for colour (scale 1-9, 9 = darkest green) and free of pale (blond) peas (1-9, 9 = totally free). The organoleptic testing of the peas was made by a trained taste panel. The results of the organoleptic and chemical analysis (sugars, ascorbic acid, dry matter, dietary fibre, alcohol insoluble solids (AIS) and surface colour) will be given in a later publication by *Kidmose and Grevsen* (13). The results of the analysis for AIS in relation to TR are presented here. The AIS values were determined according to *Townsend et al.* (23).

Climatic conditions in 1989 and 1990

In Table 2 the monthly climatic data for the 1989

and 1990 growing season are shown. 1989 had a warm and dry spring followed by a near normal summer. 1990 had a very warm spring followed by a very wet and overcast June and a relatively cold July.

Results

Yield, grading and temperature sums

The yield of shelled peas at TR 110 for early and late sowing are shown in Table 3 and 4 respectively, together with plant density, temperature sum > 4.5°C from sowing until harvest at TR 110, total yield of plant material, relative yield and DK-sieve-size. Analyses of variance were carried out on these results and the LSD_{0.05} are shown. In Figure 1 the yields of shelled peas for early and late sowing are compared within year.

The average yield of the early sowing time (Table 3) for both years was about 5.5 t/ha. The standard variety 'Avola' yielded about 6 t/ha. The varieties 'Dewdrop' and 'Marinka' had low yields in both years even considering their small DK-sieve-size of 8.3. 'Karisma' was the highest yielding variety with a medium to large DK-sieve-size of 9.2.

Table 3. Results of early-sown pea varieties in 1989 and 1990. The varieties are ranked in order of earliness in 1989. *Resultater fra tidlig såning i 1989 og 1990. Sorterne er sorteret efter tidlighed i 1989 forsøget. TR: tenderometerværdi; DK-sieve-size: vægtet gennemsnit af størrelsesfordelingen.*

Variety Sort	Plants per m ² <i>Planter pr. m²</i>		Temperature sum >4.5°C <i>Temperatursum >4,5°C</i>		Total yield of plant material, t/ha <i>Total plantemasse, t/ha</i>		TR at harvest <i>TR ved høst</i>		Adjusted yield at TR 110, t/ha <i>Korrigeret udbytte ved TR 110, t/ha</i>		Yield relative to Avola, % <i>Udbytte, relativt til Avola, %</i>		DK-sieve- size, mm <i>Vægtet gennemsnit, mm</i>	
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
'Avola'	111	98	575	707	28	40	95	99	6.0	5.9	100	100	9.4	9.3
'Lambado'	119	106	605	713	26	44	94	90	5.8	5.7	96	97	8.1	8.3
'Cobalt'	108	88	605	730	27	39	100	87	6.0	3.2	100	54	8.2	8.1
'Marinka'	107	96	625	745	25	37	100	104	4.3	2.5	71	42	8.5	8.3
'Sunroy'	106	108	680	756	29	45	152	97	5.5	4.7	90	80	8.7	8.3
'Solist'	57	96	683	804	24	42	131	94	5.0	7.2	83	122	9.6	9.1
'Chico'	103	63	684	856	29	36	144	102	5.6	4.1	92	69	8.7	8.4
'Karisma'	105	113	685	841	33	43	107	102	8.1	8.6	133	146	9.0	9.3
'Turon'	106	107	689	833	27	46	105	100	5.9	6.3	97	107	8.3	8.8
'Ator'	87	110	695	828	29	45	100	107	5.8	5.4	96	92	8.6	8.9
'Dewdrop'	110	93	701	834	29	32	102	102	4.3	1.5	71	25	8.3	–
Mean	102	98			28	41			5.7	5.0			8.7	8.7
LSD _{0,05 var}	6	10			5	3			1.0	0.9			0.1	0.1
LSD _{0,05 year}					1.2				0.29				n.s.	

LSD_{0,05 var} is the least significant difference within columns. LSD_{0,05 var} er den mindste signifikante forskel inden for rækkerne.

LSD_{0,05 year} is the least significant difference between columns. LSD_{0,05 år} er den mindst signifikante forskel mellem rækkerne.

Table 4. Results of late-sown pea varieties in 1989 and 1990. The varieties are ranked in order of earliness in 1989. *Resultater fra sen såning i 1989 og 1990. Sorterne er sorteret efter tidlighed i 1989 forsøget. TR: tenderometerværdi; DK-sieve-size: vægtet gennemsnit af størrelsesfordelingen.*

Variety <i>Sort</i>	Plants per m ² <i>Planter pr. m²</i>		Temperature sum >4.5°C <i>Temperatursum >4,5°C</i>		Total yield of plant material, t/ha <i>Total plantemasse, t/ha</i>		TR at harvest <i>TR ved høst</i>		Adjusted yield at TR 110, t/ha <i>Korrigeret udbytte ved TR 110, t/ha</i>		Yield relative to Avola, % <i>Udbytte, relativt til Avola, %</i>		DK-sieve- size, mm <i>Vægtet gennemsnit, mm</i>	
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
'Avola'	104	88	691	708	29	20	106	104	5.9	2.7	77	48	9.6	9.7
'Cobalt'	97	83	707	738	23	21	103	103	3.9	2.5	51	45	8.2	8.2
'Lambado'	108	84	717	742	26	25	97	106	5.2	4.3	68	77	7.8	8.4
'Marinka'	98	76	739	772	28	19	95	99	4.4	2.3	57	41	7.8	8.1
'Sunroy'	96	86	756	790	33	35	97	102	6.2	5.8	81	104	8.5	8.8
'Chico'	98	110	780	849	34	32	100	112	6.2	5.3	80	95	8.7	8.7
'Solist'	103	85	781	810	35	28	91	120	9.1	5.8	119	104	9.4	9.9
'Dewdrop'	99	85	786	826	34	27	105	110	5.0	4.0	65	71	8.5	8.3
'Karisma'	91	82	798	815	39	29	93	115	9.3	5.9	121	105	9.1	9.2
'Ator'	85	83	804	826	35	32	101	105	4.8	4.7	63	84	8.7	8.7
'Turon'	97	89	824	859	39	34	82	105	7.7	5.6	100	100	8.3	8.8
Mean	98	86			32	27			6.2	4.4			8.6	8.8
LSD _{0.05 var}	8	12			5	2			1.6	0.5			0.2	0.1
LSD _{0.05 year}					1.2				0.34				0.05	

LSD_{0.05 var} is the least significant difference within columns. LSD_{0.05 var} er den mindste signifikante forskel inden for rækkerne.

LSD_{0.05 year} is the least significant difference between columns. LSD_{0.05 år} er den mindste signifikante forskel mellem rækkerne.

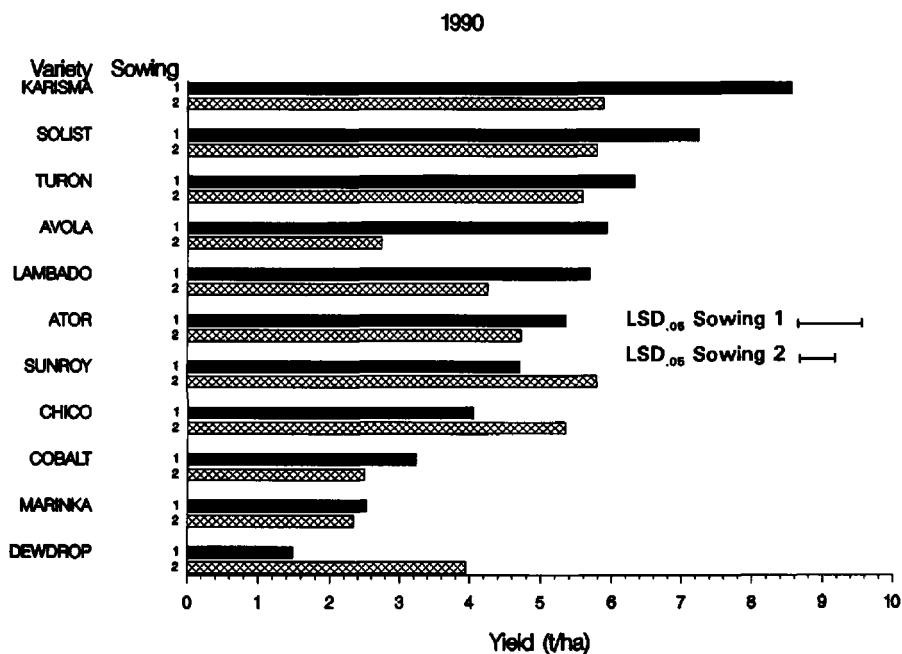
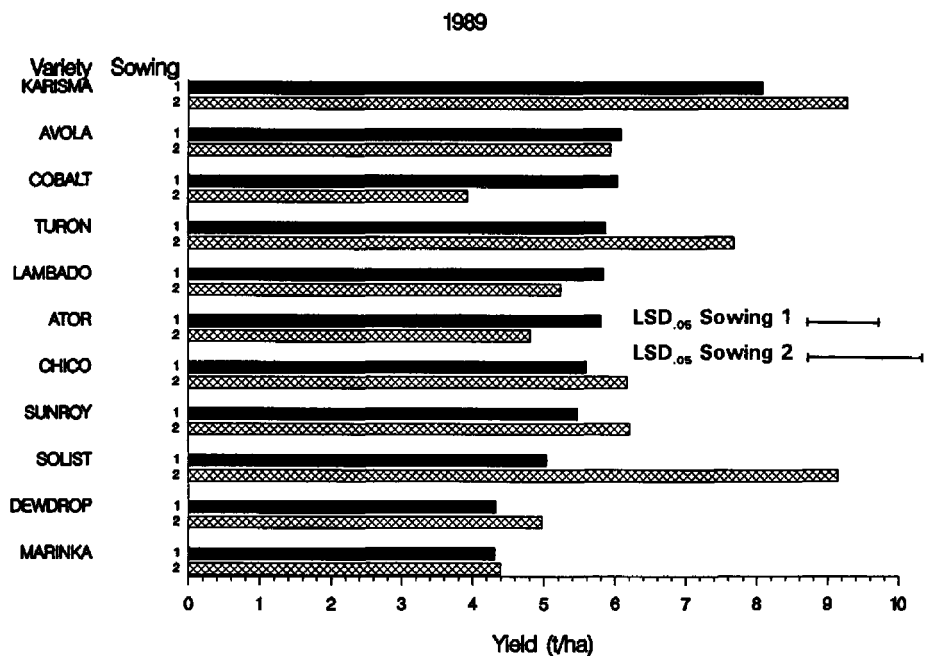


Figure 1. Yield of shelled peas in 1989 and 1990 for early (1) and late (2) sowing dates. The varieties are ranked in order of yield in the early sowing date.

Udbytte af rensede ærter i 1989 og 1990 ved tidlig (1) og sen (2) såning. Sorterne er sorteret efter udbytte ved tidlig såning.

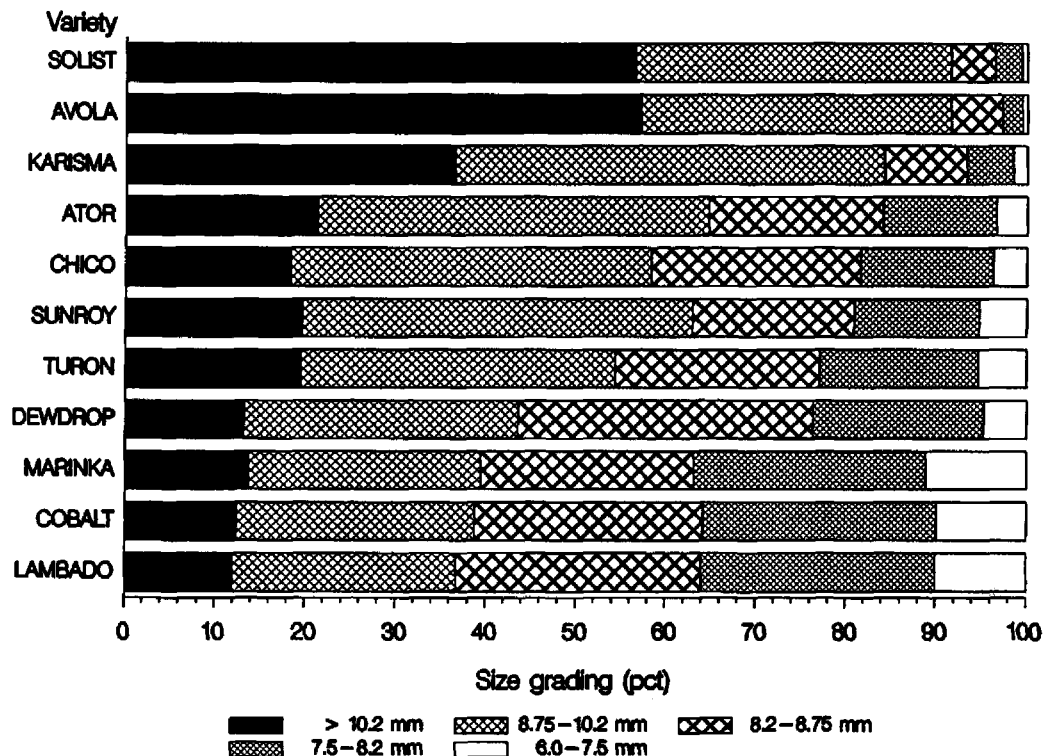


Figure 2. The average size grading of 11 pea varieties. The varieties are ranked in order of a weighed average size (DK-sieve-size).

LSD _{0.05}	>10.2 mm:	8.2%
	8.75-10.2 mm:	8.0%
	8.2-8.75 mm:	4.1%
	7.5-8.2 mm:	5.1%
	6.0-7.5 mm:	2.7%

Den gennemsnitlige størrelsesfordeling af 11 ærtesorter. Sorterne er sorteret efter en vægtet gennemsnitsstørrelse (DK-sieve-size).

The plant densities of 'Solist' in the early sowing of 1989 and 'Chico' in 1990 were only 60% of the intended plant density, and the yields are therefore about 10% lower than expected according to *Jensen* (11) and *Biddle* (2).

The yields of shelled peas in the late sowing (Table 4) in 1990 were reduced in some of the varieties compared to 1989 because of infection by Pea Enation Mosaic Virus (PEMV). The average yield for the late sowing was 6.2 t/ha in 1989 compared to only 4.4 t/ha in 1990. The standard variety 'Turon' yielded 7.7 t/ha in 1989 and 5.6 t/ha in 1990. 'Cobalt', 'Marinka' and 'Dewdrop' were low yield-

ing varieties with small sieve-sizes. 'Karisma' and 'Solist' showed high yields at both late sowing dates. The variety 'Solist' had one of the largest DK-sieve-sizes with an average of 9.6. 3 of the varieties - 'Sunroy', 'Chico' and 'Dewdrop' - showed higher yields at the late sowing dates compared to early sowing dates in both years (Fig. 1). In the late sowing of 1990 the variety 'Avola' was strongly affected by the PEMV infection and yielded only 2.7 t/ha compared to 5.9 t/ha in 1989.

Statistical analysis of the results showed a highly significant difference in yield between years for both early and late sowing dates with higher yields in 1989.

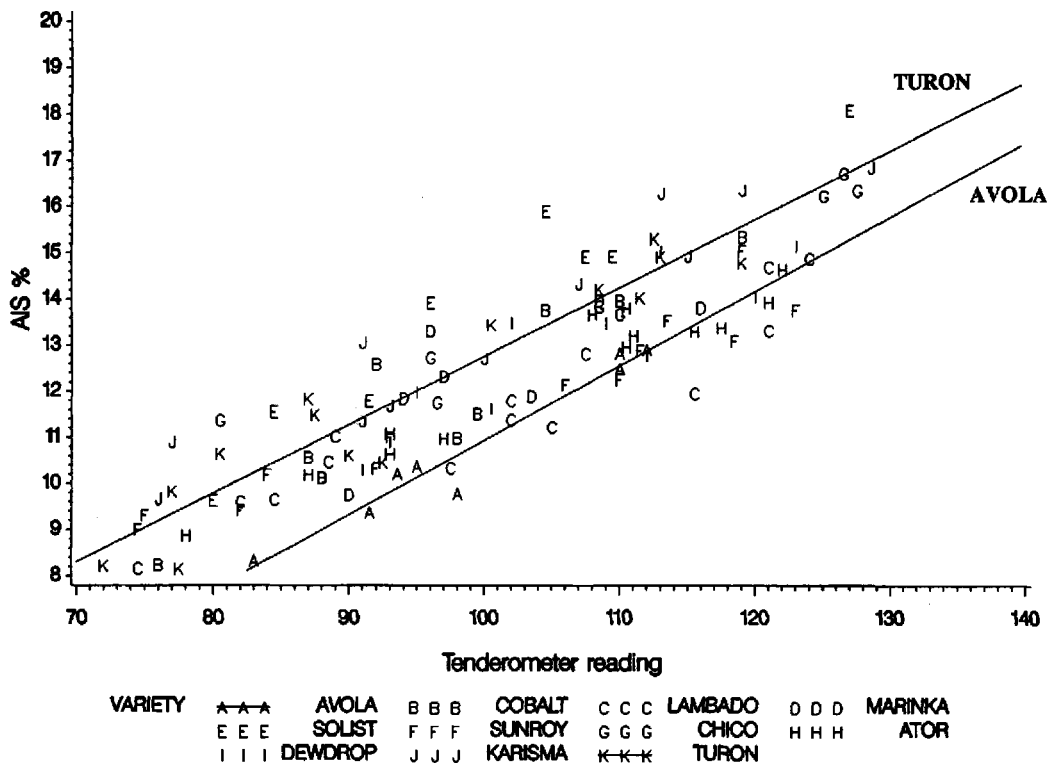


Figure 3. Alcohol insoluble solids (AIS) values of the 11 pea varieties in relation to tenderometer readings. Values of 2 years, 2 sowing dates and 5 size gradings are included. The linear relationships for the standard varieties 'Avola' and 'Turon' are shown.

Indholdet af alkohol uopløseligt tørstof (AIS) i 11 ærtesorter i relation til tenderometerværdi (TR). Den lineære sammenhæng for AIS og TR i målesorterne 'Avola' og 'Turon' er indtegnet.

The difference in yield of the varieties was also highly significant as well as the interaction between year and variety. Because of the interaction between year and variety the results of yield and related results are shown for each year (Table 3 and 4). The total mass of plant material was significantly higher in the early sowing of 1990 but significantly lower in the late sowing of 1990 compared to 1989.

The varieties 'Avola', 'Solist' and 'Karisma' were large sized peas having more than 80% of the peas larger than 8.75 mm in diameter (Fig. 2). The varieties 'Ator', 'Sunroy', 'Chico' and 'Turon' were medium to small sized with between 55% and 65% larger than 8.75 mm. 'Dewdrop', 'Cobalt', 'Marinka' and 'Lambado' were small to 'petit pois' sized with less than 45% larger than 8.75 mm.

The temperature sums > 4.5°C of the varieties (Ta-

ble 3 and 4) were not consistent from early sowing time to late sowing time or from year to year, but the ranking with respect to reaching harvest TR 110 was relatively stable. 'Avola' was the earliest variety together with 'Lambado' and 'Cobalt'. 'Turon' was the latest variety together with 'Ator' and 'Dewdrop'. The variety 'Chico' showed a diverging later maturation in 1990 than in 1989.

Plant growth

The period of time from sowing to emergence was 20 days on average for the early sowing and 10 days for the late sowing. The period from emergence until beginning of flowering was 30 to 45 days for the early sowing and 27 to 42 days for the late sowing. The average duration of flowering was 10 days for the early sowing in 1989 compared to 27 days

Table 5. Botanical data of 11 pea varieties. Average of 4 trials.
Botaniske værdier af 11 ærtesorter. Gennemsnit af 4 forsøg.

Variety Sort	Plant height, cm <i>Plantehøjde, cm</i>	No. of the 1. node with a pod <i>Nr. på det 1. nodie med bælg</i>	Number of nodes with pods <i>Antal bærende nodier</i>	Number of pods per plant <i>Antal bælg pr. plante</i>	Number of pods per node <i>Antal bælg pr. nodie</i>
'Avola'	71	9	4.2	5.0	1.2
'Lambado'	66	12	4.1	7.6	1.8
'Cobalt'	65	10	5.7	8.0	1.4
'Marinka'	54	11	4.6	7.8	1.7
'Sunroy'	88	14	4.0	7.1	1.8
'Solist'	74	13	3.3	5.2	1.6
'Chico'	85	13	3.8	6.7	1.8
'Karisma'	90	14	3.2	5.1	1.7
'Turon'	64	15	3.6	5.6	1.6
'Ator'	71	15	4.4	7.2	1.6
'Dewdrop'	68	16	3.8	8.2	2.2
Mean	72	13	4.1	6.7	1.7
LSD _{0.05}	20	1	0.8	1.4	0.3

for the early sowing in 1990. The period of flowering in the late sowing was in both years about 15 days.

The botanical records are shown in Table 5. The plants were about 40 cm higher in the early sowing of 1990 than in 1989. 'Karisma', 'Sunroy' and 'Chico' had long vines of nearly 1 meter. The variety 'Solist' had long vines in the early sowing but relatively short in the late. 'Marinka', 'Cobalt' and 'Turon' had short vines of about 60 cm.

The number of nodes up to the first pod was very constant for the single varieties with 9 in 'Avola' as the lowest and 15 to 16 in 'Ator' and 'Dewdrop' as the highest. The number of pods per plant was in average 3 higher in the early sowing in 1990 than in 1989, but this did not result in higher yields. 'Dewdrop' was the only triple pod variety in this experiment. 'Cobalt', 'Ator', 'Karisma' and 'Chico' had a more or less curved and pointed pod shape, whereas the rest were blunt and more or less straight.

Quality evaluation

The results of the visual evaluation of colour and pale peas ('blonds') of the varieties are shown in Table 6. 'Marinka', 'Solist' and 'Dewdrop' were the most dark green varieties and they also had very few

pale peas together with 'Sunroy' and 'Ator'. The varieties 'Avola', 'Cobalt', 'Lambado' and 'Chico' were light green coloured and had an unacceptably high content of pale peas. The peas from early sowing in 1990 were generally very light green and showed a high degree of pale discoloration.

Alcohol insoluble solids (AIS)

Figure 3 shows the relationship between AIS and TR for both years, the 2 sowing dates per year, and all 5 size grades in the 11 varieties. The correlation between TR and AIS is high, and a linear relationship of AIS versus TR and variety could explain 92% of the variation in the data ($R^2 = 0.92$). The linear regressions between AIS and TR of the 11 varieties in Figure 3 are given in Table 7 together with the AIS values according to the TR values of 100 and 110. The difference between varieties is significant and shows high AIS values in the varieties 'Solist' and 'Karisma'. The lowest AIS values in relation to TR are found in the varieties 'Avola', 'Lambado', and 'Sunroy'. Further results from analyses of nutritive value, taste testings and correlations with AIS will be given by *Kidmose and Grevsen* (13).

Table 6. Visual quality evaluation of blanched samples from 11 pea varieties. Average of 4 trials.

Visuel kvalitetsbedømmelse af blancherede ærteprøver fra 11 ærtesorter. Gennemsnit af 4 forsøg.

Variety Sort	Green colour	Free of pale peas
	1 to 9, 9 darkest green	1 to 9, 9 totally free
	<i>Grøn farve</i>	<i>Fri for gule</i>
	<i>1 til 9,</i>	<i>1 til 9,</i>
	<i>9 mørkest grøn</i>	<i>9 helt fri</i>
'Avola'	4.2	3.6
'Lambado'	3.9	4.0
'Cobalt'	3.9	3.2
'Marinka'	6.5	6.8
'Sunroy'	6.2	6.3
'Solist'	6.9	7.1
'Chico'	3.9	4.2
'Karisma'	5.5	5.5
'Turon'	4.8	4.0
'Ator'	5.7	6.5
'Dewdrop'	8.2	7.6
Mean	5.4	5.3
LSD _{0.05}	1.4	2.1

Table 7. Linear regression between alcohol insoluble solids (AIS) and tenderometer readings (TR) of 11 pea varieties. AIS values according to TR 100 and 110 are calculated.

(Lineær regressioner mellem alkohol uopløseligt tørstof (AIS) og tenderometer værdi (TR) for 11 ærtesorter. AIS-værdierne til TR: 100 og 110 er beregnet.

Variety Sort	Linear regression <i>lineær regression</i>	AIS value at TR	
		100	110
	$AIS = b_1(TR) + b_0$		
'Lambado'	0.11(TR)-0.29	8.1 a	11.8 a
'Avola'	0.15(TR)-4.56	10.4 b	11.9 a
'Sunroy'	0.11(TR)+0.39	11.4 bc	12.5 a
'Ator'	0.12(TR)-0.13	11.9 bc	13.1 ab
'Marinka'	0.13(TR)-0.71	12.3 bc	13.6 ab
'Dewdrop'	0.13(TR)-0.64	12.4 bc	13.7 ab
'Turon'	0.15(TR)-2.37	12.6 bc	14.1 ab
'Cobalt'	0.16(TR)-3.18	12.8 bc	14.4 ab
'Chico'	0.11(TR)+2.29	13.2 bc	14.4 ab
'Karisma'	0.14(TR)-0.20	13.8 c	15.2 b
'Solist'	0.14(TR)-0.19	13.8 c	15.2 b

Values followed by the same letter are not significantly different at a 95% level. The varieties are ranked in order of increasing AIS values.

Værdier efterfulgt af samme bogstav er ikke signifikant forskellige på 95% niveau. Sorterne er opstillet efter stigende AIS-værdier.

Discussion

Early sowing of peas (for both green and dry harvesting) is found to give higher yields than late sowing (2, 16, 19, 22), but this was not apparent from the results presented here (Table 4 and 5). In 1989 the average yield of the late sowing was higher than the yield of early sowing. In 1990 the average yield of the late sowing date was lower than the early sowing, but this did not apply to all varieties and was partly an effect of the PEMV attack (18). The varieties 'Avola', 'Lambado' and 'Karisma' were most severely affected by the virus. Other factors in the actual season such as temperature, rainfall distribution, and light intensity are important for the yield level besides day length. These findings confirmed the results found in an experiment by Jensen and Friis (12), where the influence of sowing date on yield of vining peas was investigated. Their results showed that only one year out of three years of experiments gave a significant lower yield as an effect of late sowing date.

The Danish freezing companies grade and retail their pea products in the same grading classes as used in the present experiment. For some years the Danish industries have been looking for new early varieties with medium to small sieve-sizes. The small sized pea varieties in this experiment - 'Cobalt', 'Marinka', 'Dewdrop' and 'Lambado' - have not been accepted for production because of low yields and/or quality problems.

In the 1989 experiment the temperature sum > 4.5°C from sowing until harvest at TR 110 were on average 100 units higher in the late sowing than in the early. This result is in agreement with other findings in peas (12, 17) and in other vegetable crops (8, 25, 26). The usually higher temperature sum values of late sowing or planting are explained by the lower light intensity during late summer and autumn in northern countries (Table 2).

In contrast to the result in 1989 the 1990 experiment shows temperature sum values that were on average the same for early and late sowing dates (Table 3 and 4). In 1990 the solar radiation of June (Table 2) was very low (heavy rainfall and overcast), and accordingly the development of the early sown peas resembled the development of late sown peas. The conflicting results point out that temperature sum values are not universal values for development in peas. The temperature sum values from sowing until harvest for the individual varieties can show great variation from year to year and

from sowing date to sowing date (here about 20%) as also stated by *Buishand and Riepma* (6) and *Rosenfeldt* (20). On the other hand the use of 'thermal time' is still better in planning the harvest sequences than 'number of days' from sowing until harvest which may show even more variation (7, 15). 'Thermal time' also gives a possibility to follow up and adjust the harvest plans according to actual weather during the season.

The growth of the pea plants was affected by the unusual overcast and wet June of 1990. The heavy rainfall and low solar radiation lead to development of long vines, prolonged flowering periods and high amounts of total plant material. The vine length of the early sown crop was about 60% longer than the average vine length in the 1989 trial. The total mass of plant material was about 40% higher. The average number of pods per plant was 8 at early sowing in 1990 compared to 5 at early sowing in 1989 together with a period of flowering of 27 days instead of 10 days. A long and undetermined flowering period results in an uneven maturation and therefore lower quality. The extra pods in 1990 did not result in higher yield.

The curved, tight (pods filled out with peas) and pointed pods of the varieties 'Cobalt', 'Chico' and 'Ator' are difficult to thresh and tend to cling to the screens in the pea combiner. Varieties with this pod type are therefore undesirable to the Danish freezing industry. Straight blunt pod types like 'Avola' with room around the pea seeds are easy to open in the viners, and can be threshed with lower force. The lower force again results in less damage, less waste and a better quality of the product.

The best quality with respect to colour was found in the varieties 'Marinka' and 'Dewdrop'. Unfortunately these 2 varieties also had the lowest yield potentials in both years. Even good colour was also found in 'Sunroy', 'Solist' and 'Ator'. The product of early sown peas in 1990 contained more pale 'blond' peas than any other crops in the 2 years of experiment. As also stated by *Biddle* (2) this is an effect of the wet June in 1990 and the long heavy lodging vines, which have shaded many of the pods. Blond peas gives an unattractive frozen product and makes colour sorting necessary. The standard variety 'Avola', which is grown extensively because of its earliness and yield, had a very high content of pale peas (Table 6). Unacceptable low colour quality is the main reason why a new early but still high yielding variety is wanted.

Deep frozen peas are marketed according to

size grading, TR, and increasingly according to AIS value. AIS values higher than 13.0% in a first class small sized (under 8.75 mm) pea product are not allowed (1). The medium sized (8.75–10.2 mm) first class product must not exceed an AIS value of 15.0% and for the large size (over 10.2 mm) the maximum AIS value is 17.0%. The Danish industry produces a special 'AA grade' quality where the AIS limits are 0.6% lower than the above mentioned.

The high correlation of AIS and TR found in this experiment was previously stated by *Ottoson* (17) and more recently by *Westerling and Schijvens* (24) and *Schijvens et al.* (21). The slopes of the linear relationships between AIS and TR found here (Fig. 3 and Table 7) are comparable to the findings of *Westerling and Schijvens* (24) although in general a little steeper. The reason for this can either be genetic differences or differences in the climatic growing conditions in Denmark compared to The Netherlands. Steep slope of the regression AIS versus TR is although not enough to indicate high level of AIS as seen in the variety 'Avola'. The AIS values of the varieties 'Solist' and 'Karisma' are considerably higher than the normally found AIS values in relation to TR and this is an indication of low quality in respect to mealiness (21).

Conclusion

The yield of shelled peas showed large variations between years and sowing dates. In general early sowing did not produce the highest yields, and some varieties ('Sunroy', 'Chico' and 'Dewdrop') performed better at late sowing dates.

Alcohol insoluble solids (AIS) values were highly correlated with tenderometer readings (TR). The relationship allowed a separation of 2 varieties ('Solist' and 'Karisma') with high AIS in relation to TR which is an indication of poor organoleptic quality.

The 2 new varieties ('Cobalt' and 'Lambado') which mature very early could not replace the known very early varieties because of low quality in respect to colour. The high yielding large sized pea varieties ('Karisma' and 'Solist') were of low quality with respect to high AIS value. The small sized pea varieties were either low in yield ('Marinka' and 'Dewdrop') or had low quality with respect to colour ('Cobalt', 'Lambado' and 'Chico'). The medium sized varieties ('Sunroy' and 'Ator') were medium in yield and of good colour quality.

The value of the temperature sum $> 4.5^{\circ}\text{C}$ from sowing to harvest showed differences of about 20% as an effect of the actual weather in the growing period. A more complex growth model of peas is needed for better planning and prediction of the harvest dates.

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