AN AGRICULTURAL EXPERIMENT IN THE UNPROTECTED SALT MARSH
Part II

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CONTENTS

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1. INTRODUCTION

The possibility of growing crops on brackish soil in connection with habitation in the Dutch coastal (*terpen*) area is discussed by van Zeist *et al.* (1976). That study was the result of experiments carried out for seven years on the unprotected salt marsh north of the Westpolder (municipality of Ulrum, province of Groningen). The experiments were continued for another three years (1976-1978).

For detailed information on the aim of this study, the location of the experimental field (fig. 1) and the description of the agricultural crops used, the reader is referred to the report of the preceding seven years (van Zeist *et al.*, 1976).

The experiment generally is a continuation of the field study mentioned above. The location and dimensions of the plots are the same. A scheme of the field is given in fig. 2. Apart from attempting to confirm the preceding results some new crops were tried. Some aspects were now studied in more detail.

In addition to the crops grown during the period 1969-1975, *Triticum aestivum*, *T. spelta*, *T. dicoccum* and *Brassica rapa* were tried. Another cruciferous plant sown was *Brassica oleracea*. Seed was collected from plants originating from Bretagne. Attention was paid to differences in white-flowered and (old-fashioned) blue-flowered flax, whereas also two-row and four-row barley were compared. *Camelina sativa* was no longer included in the experiment as the behaviour of this plant had already proved very constant under the given conditions.

For some crops growth curves are given (figs. 4-8). Harvest data are also given in these figures. For those crops for which no growth curve is presented harvest data are mentioned in the text. General results are presented in table 2.

2. WEATHER CONDITIONS AND TIDAL FLOODS

Precipitation, minimum night- and maximum day-temperatures are shown in fig. 3. These data were kindly supplied by Ing. K. P. Wouda (Mansholt's Veredelingsbedrijf, Ulrum).

High tide exceeding 2.05 m was reported by Rijkswaterstaat, directie Friesland (see table 1).

Fig. 1. Location of the experimental field (indicated by an arrow) in the undiked marsh near the Westpolder.

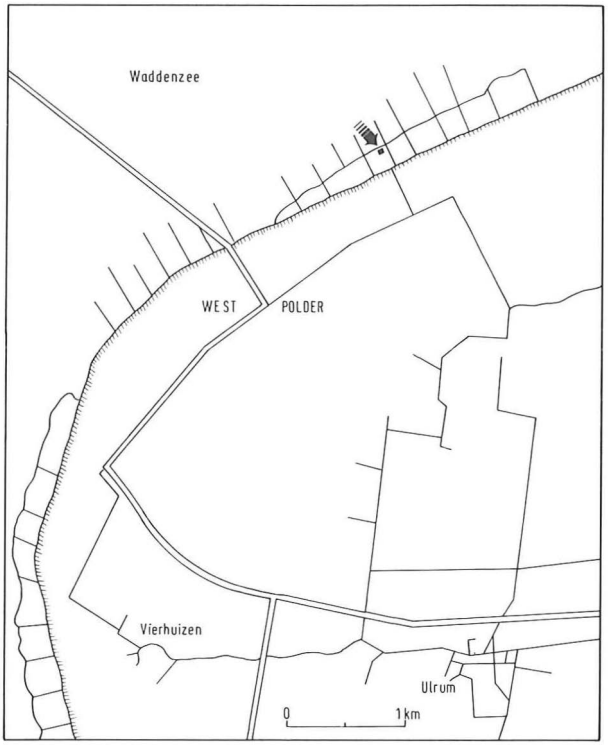

TABLE 1

High tides in metres above 2.05 m NAP, recorded at Lauwersoog.

1976		1977		1978	
date	height	date	height	date	height
3-1	3.33	1-10	2.35	4-1	2.31
	3.72	12-11	2.24	12-9	2.05
20-1	3.41		2.50	16-11	2.12
21-1	2.50	13-11	2.70		
22-1	3.05		2.19		
1-12	2.20	14-11	2.80		
		15-11	2.76		
		24-11	2.30		
		30-12	2.24		
		31-12	3.20		

3. PROGRESS OF THE RESEARCH

3.1. The 1976 Season

General

The very dry weather strongly influenced the growth of the various crops. It was observed that this drought effect was not of equal intensity all over the field. It was most pronounced in the northwestern corner and least in the southeast. Various factors would have been responsible for this gradient. From north to south there is a drainage effect, as the steep erosion edge was not more than about 3-5 m away from the north side of the field. In the course of ten-year experiments the edge slowly crept towards the field as the winter storms caused it to cave in.

Northwestern winds, that are quite common in the area, bring salt as they blow over the Wadden Sea. This has a marked effect on the front row of plants which have a protective function for the plants behind. The resulting salt content is also higher in the northern part because of the drainage effect. Thus conditions can vary quite a lot on plots of a few square metres. Crops were sown on April 9th, apart from *Triticum spelta* and *Brassica rapa*, that were sown on April 15th.

Linum usitatissimum (A-5; B-5) (B-7)
The white-flowered variety (A-5; B-5) (fig. 4) and the blue-flowered flax (B-7) started germinating in the first week of May. By mid-May 25% had germinated on A-5 and on B-5 and B-7 50% and 40% respectively. After a rainy period in June another 5% flax-seed germinated, so that plants of 30-50 cm occurred with plants of 3-5 cm in between. From the last week of June until the harvest on July 22nd the flax did not grow visibly. The blue-flowered variety was ca. 10 cm shorter than the white variety and also had a lower seed production.

Vicia faba var. *minor* (A-1; B-1)
In field A-1 not a single bean sprouted. In B-1 less than 10% germinated but only a few plants remained, reaching about 5-10 cm towards the end of June. By mid-July they were up to 16 cm tall. Some produced poor flowers together with yellow leaves. A week later all plants were gone.

Hordeum distichum (B-8)
Four rows of two-row barley were sown on plot B-8 to compare with *Hordeum vulgare*. At the beginning of May this barley was up to 10 cm high. Two months later these plants measured about 40 cm and were producing ears. The development of the ears however was very poor, giving hardly any yield. The sparse yield was finally eaten by birds.

Hordeum vulgare tetrastichum (A-4; B-4)
Four-row barley was sown on A-4 and B-4; only 250 gr. of the breed "Bigo" was available. Germination was good but in the course of May some plants dropped out. The plants in the B-field were about 10 cm taller than those in the northern (A) plot. This difference is reflected to some extent in the yield.

Avena sativa (A-3; B-3)
Germination and initial growth were better on the northern plot. In the course of June, however, the crop on the southern (B) plot increased and surpassed that on the A-plot, being about 10% higher. This is also visible in the very moderate yield, harvested on July 22nd.

Panicum miliaceum (B-6)
Germination took seven weeks and then only

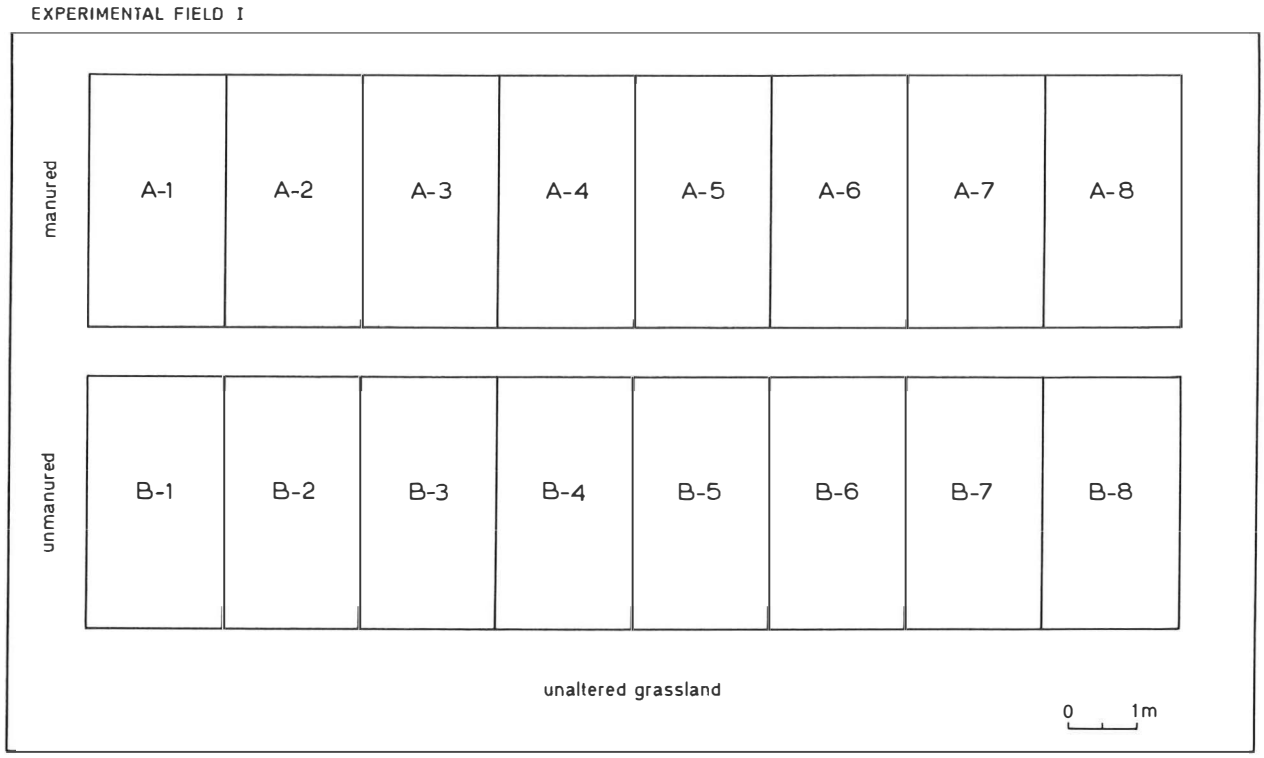

TABLE 2

Data on input and yield on the experimental field in the undiked salt marsh near the Westpolder.

	input in g	yield in g	yield/input ratio	calculated yield in kg/ha	input in g	yield in g	yield/input ratio	calculated yield in kg/ha
			A				B	
				1976				
Linum usitatissimum fl. white	60	26	0.43	35	60	240	4.0	340
Linum usitatissimum fl. blue	–	–	–	–	60	70	1.2	100
Vicia faba var. minor	180	–	–	–	180	–	–	–
Hordeum distichum	–	–	–	–	65	–	–	–
Hordeum vulgare tetrastichum	125	310	2.5	440	125	560	4.5	800
Avena sativa	130	52	0.4	75	130	195	1.5	280
Panicum miliaceum	–	–	–	–	60	16	0.27	22
Triticum aestivum	130	1	0.01	1.4	130	31	0.24	44
Triticum spelta	40	–	–	–	–	–	–	–
Triticum dicoccum	60	37	0.62	52	–	–	–	–
Brassica rapa var. silvestris	20	95	4.75	135	–	–	–	–

◄ Fig. 2. Experimental field I.

amounted to about 5%. Some plants reached about 45 cm. By the second week of August the leaves had turned brown. On September 3rd a very poor crop was harvested.

Triticum aestivum (A-2; B-2)
Germination and growth was very poor. At first development on the northern plot was better, but this crop was overtaken in terms of growth towards the end of June by the crop on the B-plot.

Triticum spelta (A-7)
40 gr. were sown; 10 plants developed and reached 40 cm. All the spelt plants died before producing any ears.

Triticum dicoccum (A-7)
Germination was about 30% and the biggest plants reached 55-60 cm. The ripening process took more time than in the other cereals.

Brassica rapa (A-8)
The summer rape obtained from the Zentralinstitut für Genetik und Kulturpflanzenforschung, Gatersleben (D.D.R.) was named there: *Brassica rapa* L. var. *silvestris* (Lam. Briggs) f. *preacox* (DC)Mansf., listed under assortments number BRA 40/74 and called "Maleksberger". The amount of seed was sufficient for half a plot. The first seeds germinated at the beginning of May. By mid-June the plants were 20-60 cm high. A month later maximum size was 75 cm and part of the crop was already ripe.

Brassica oleracea (A-8; B-8)
Cabbage was sown in two rows. Germination was good. The plant is biennial and thus flowers after one year. Some of the plants were left in the experimental field, some were taken by one of us (T. C. van Hoorn) and put in a garden to allow for any necessary restocking.

3.2. The 1977 Season

Linum usitatissimum (A-6; B-6) (A-8)
White-flowered flax (A-6; B-6) and blue-flowered flax (A-8) germinated very well. There was a clear difference between the white flax on plot A-6 and that on B-6, while the blue flax lagged behind the white variety on the corresponding plot. In the

input in g	yield in g	yield/input ratio	calculated yield in kg/ha	input in g	yield in g	yield/input ratio	calculated yield in kg/ha	input in g	yield in g	yield/input ratio	calculated yield in kg/ha	input in g	yield in g	yield/input ratio	calculated yield in kg/ha
A				B				A				B			
1977								1978							
60	265	4.4	380	60	300	5.0	430	60	90	1.5	130	60	373	6.2	530
60	450	7.5	640	–	–	–	–	60	71	1.2	100	60	130	2.2	185
180	1455	8.1	2080	180	2565	14.3	3665	180	1232	6.8	1760	180	2970	16.5	4240
130	230	1.8	328	–	–	–	–	130	–	–	–	130	–	–	–
125	1650	13.2	2360	125	1600	12.8	2285	130	255	2.0	365	130	412	3.2	590
130	2350	18.1	3360	130	2100	16.2	3000	130	52	0.4	75	130	115	0.9	165
–	–	–	–	60	–	–	–	–	–	–	–	60	–	–	–
130	255	1.9	365	130	305	2.4	435	130	–	–	–	130	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	20	565	28.3	805	–	–	–	–	20	461	23.1	660

course of the season, however, the blue variety developed a better average size but the white flax suffered from *Thrips*. Ripening took longer for the blue variety than for the white one.

Vicia faba var. *minor* (A-2; B-2)
Germination was very good. The development is shown in fig. 5. The beans were harvested on September 15th.

Hordeum distichum (A-1)
Two-row barley was sown on the plot where conditions are most unfavourable as regards sea-wind exposure. Half the grains sprouted. Some plants developed well, attaining 85 cm maximally. The yield, however, was very low.

Hordeum vulgare tetrastichum (A-5; B-5)
This barley developed well, although damage was inflicted by birds and hares. There was no visible difference between the northern and the southern plot. As germination took place at two successive times, ripening also showed two groups.

Avena sativa (A-4; B-4)
Development on both plots ran parallel. The yield from the northern plot was a little better. Harvesting took place on August 24th.

Panicum miliaceum (B-7)
Milled did not germinate.

Triticum aestivum (A-3; B-3)
Germination was not so good as in four-row barley and oats. At first growth was better than in the other cereals. Later growth declined, ears were formed with difficulty and leaves turned yellow at the tip. The crop was harvested during the last week of August.

Brassica rapa (B-1)
Rape seed grew very well and was harvested on July 25th.

Brassica oleracea (A-8; B-8)
The cabbage, sown in 1976, had developed 10 plants. By mid-May they were about 8-10 cm high and a week later three of them flowered. At the end of June they measured 30 cm and fruit-setting had started. Flowering lasted up to July 11th. The seed production was 20 gr. The yield/input ratio is not known, because the input was not weighed. The yield of a *Brassica oleracea* plant originating from Helgoland and growing on fertile sandy soil, inland, amounted to 94 gr.!

3.3. The 1978 Season

Linum usitatissimum (white-flowered A-7; B-7) (blue-flowered A-7; B-7)
In the plot B germination was more even. In the A-plot growth was not so good and the blue flax still remained shorter than the white variety. Ripening and harvesting differed by one week: August 15th and 21st for the white and blue varieties respectively.

Vicia faba var. *minor* (A-3; B-3)
The northern plot lagged behind from the beginning. At an average length of 15 and 25 cm respectively plants on the two plots showed flower buds in the third week of June. Towards the end of July plant-lice (aphids) appeared in the northern part. The biggest plant on the B-plot measured 112 cm. Harvesting took place on September 21st.

Hordeum distichum (A-8)
Two-row barley sprouted regularly. During the first few days of June the leaves started to turn yellow and growth stagnated. The few ears that developed stayed in the enveloping leaves. The remaining ears that bore seed were eaten by animals.

Hordeum vulgare tetrastichum (A-6; B-6)
Four-row barley developed well but suffered, as usual, from birds eating the seeds and hares eating the tops of the young plants. At the beginning of June some of the plants turned yellow. The ripening crop was partly eaten up by birds. Part of the crop was harvested on August 21th and the rest on September 9th.

Avena sativa (A-5; B-5)
Oats developed well, especially on the southern plot. Maximum length was 90 cm. Before the harvest, birds took most of the crop. The data in table 2 are therefore rather meaningless.

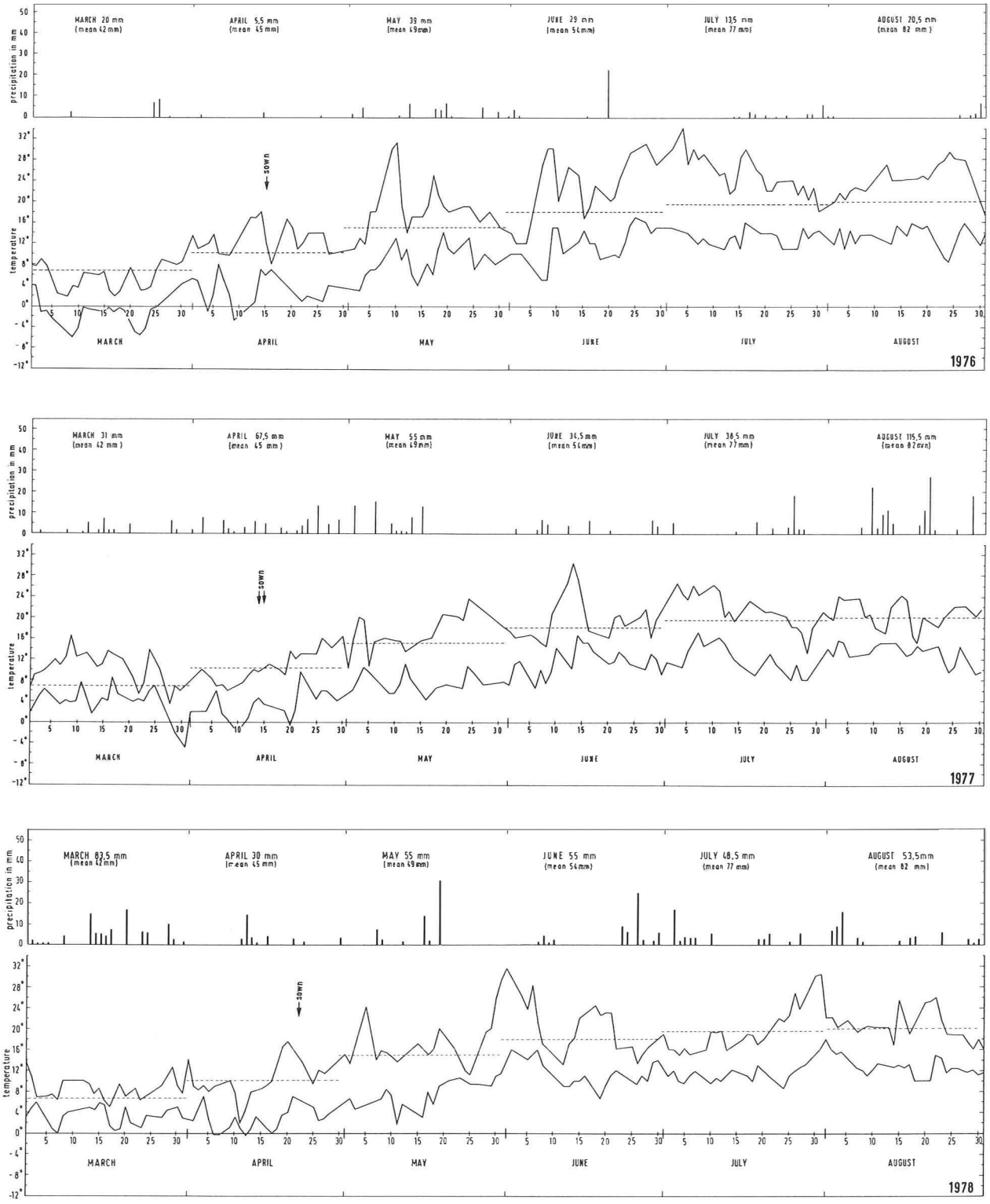

Fig. 3. Precipitation and minimum and maximum temperatures from March 1st to August 1st, 1976, 1977 and 1978, recorded at Mansholt's Veredelingsbedrijf (Plantbreeding firm) in the Westpolder. The mean temperatures and precipitation (for the period 1931-1960) are after *Atlas van Nederland*, Plates V-1 and V-3.

Panicum miliaceum (B-8)
Millet failed again although some plants reached 20-30 cm. There was no yield.

Triticum aestivum (A-4; B-4)
Wheat on the B-plot sprouted rather well. By mid-May, however, many plants had died. In the second week of July birds had eaten the remaining crop.

Brassica rapa (B-2)
Summer rape was a successful crop, flowering abundantly at the beginning of June. Damage was inflicted by caterpillars of a *Pieris* species, and also the pods were pecked out. Part of the crop was harvested at the beginning of August, the remaining part later.

Brassica oleracea (A-2)
Germination was a little irregular, especially on the seaward side. Plants reached about 20 cm maximally. As this plant is biennial, no production is to be expected this year.

4. GROWTH AND YIELD OF THE CROP

The information obtained from the seasons 1976-1978 will be discussed and compared with the results of the preceding seven years. The data are treated the same way as in van Zeist *et al.* (1976). In table 2 the data for the various crops are shown, apart from *Brassica oleracea*. Plotted are the input in grammes, the yield in grammes, the yield/input ratio and the calculated yield in kg/ha.

As previously the northern (A) plots were lightly manured with dried cattle dung. Any positive effects of manuring was generally overshadowed, however, by the deleterious effects of salt northwestern winds.

Linum usitatissimum
From 1975 onward, two flax varieties were used: the white-flowered variety that is grown nowadays and a blue-flowered variety that was grown previously in the Netherlands but that is no longer cultivated at the moment. The 1976 report states "There is no significant difference in yield apparent between the white- and blue-flowered flax". This is confirmed by the results of the three following seasons. In 1976 and 1978 the seed production of blue flax was lower than that of the white flax whereas in 1977 it was higher (table 2). The yields also fall within the limits of the first investigations. The growth-curves (fig. 4) show that the white flax is on average about 10 cm higher than the blue variety. On sandy soil in Orvelte (prov. Drenthe) the two crops also demonstrate the same tendency. Blue flax also develops more slowly than white flax and ripens later.

Vica faba var. *minor*
The Celtic bean had two successful seasons as against one season of complete failure. An unsuccessful season is caused by unfavorable conditions during the germinating stage. When flooding with salt water or a very dry spring (increasingly high relative salt content) occur during and after sowing then generally no plant will appear. When enough precipitation falls then even aphids cannot ruin the crop and a reasonable to successful yield is ensured. Fig. 5 demonstrates the difference in growth between a failing crop and two successful crops. The manured plots did not show a better yield, which is explained by the negative influence of the sea wind from which the southern plots are sheltered by the crops on the north side. The A and B curves, drawn in fig. 5, clearly demonstrate this effect.

According to Kreuz (Aerboe *et al.*, 1930) the original "Mansholt" Celtic bean averaged 0.8 gr. and had a yellow-brown colour. Offspring from Celtic beans from the same farm that were grown on the marsh averaged 0.35 gr. in 1978 and were brown in colour. From this strain, grown on poor sand, inland, the beans averaged 0.32 gr., whereas the colour was yellow. Sandy soil, heavily manured with cattle dung, gave an average of 0.37 gr. It seems that the colour is dependent upon the soil but also upon the time of harvesting (ripening).

Hordeum distichum and Hordeum vulgare tetrastichum
The results of the experiments during the period 1969-1975 suggested that four-row barley was better adapted to brackish conditions than two-row barley. This is confirmed by the results from the three last seasons.

From 1976-1978 both barleys were grown and compared (fig. 6). The picture is often obscured by

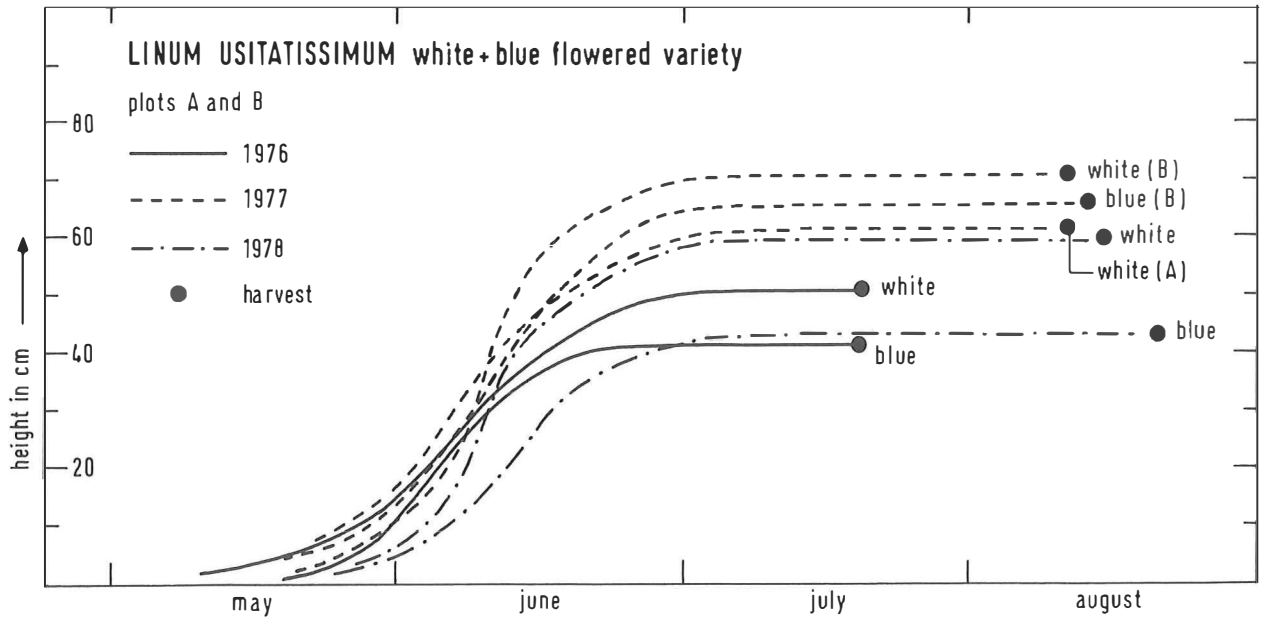

Fig. 4. Growth curves for *Linum usitatissimum*, white and blue flowered variety.

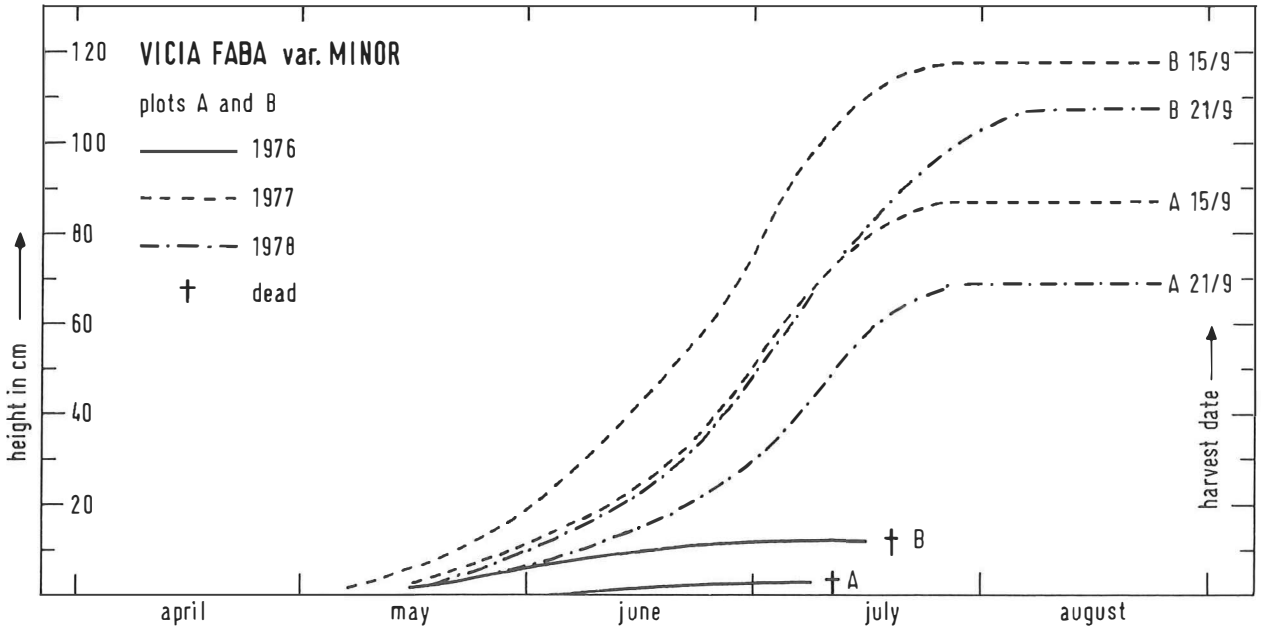

Fig. 5. Growth curves for *Vicia faba* var. *minor*.

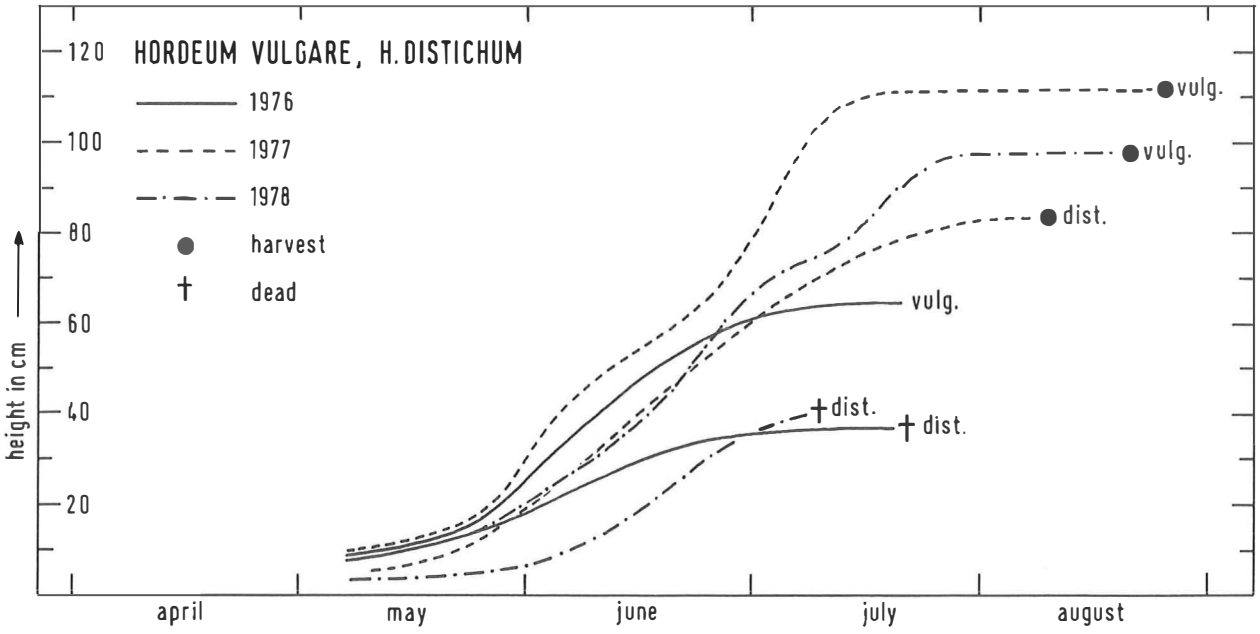

Fig. 6. Growth curves for *Hordeum vulgare* and *H. distichum*.

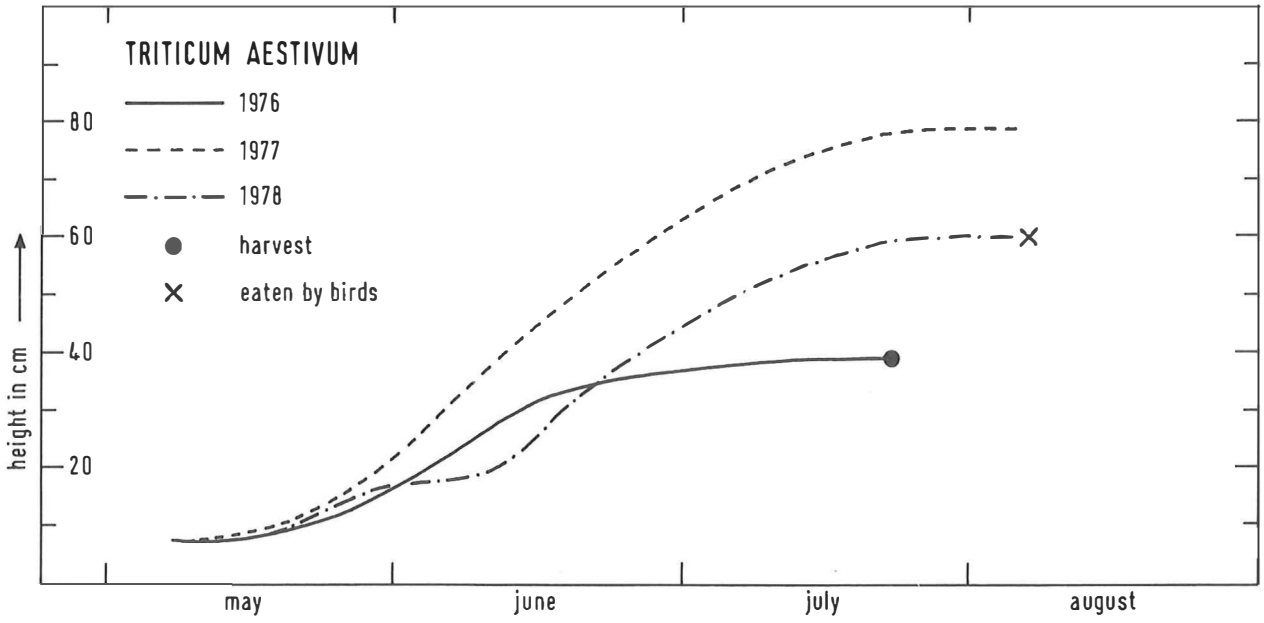

Fig. 7. Growth curves for *Triticum aestivum*.

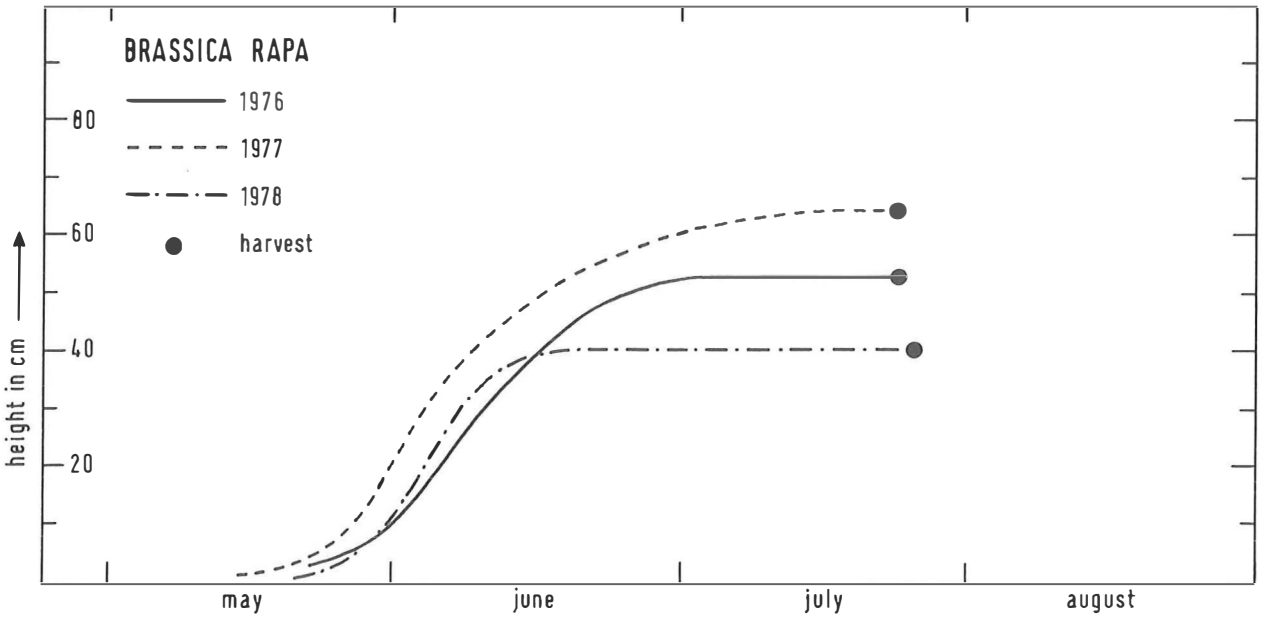

Fig. 8. Growth curves for *Brassica rapa*.

damage inflicted by birds eating barley during sowing and harvesting. Nevertheless, the facts point convincingly to *Hordeum vulgare tetrastichum* having advantages over *H. distichum*.

In three seasons four-row barley delivered three harvests as against one of two-row barley, and even when both types of barley produced a harvest the yield of the four-row barley was seven times as great as that of the two-row barley.

Avena sativa

The behaviour of oats during the period under discussion is the same as during the first study (van Zeist *et al.*, 1976). Oats sometimes give a good yield but on fewer occasions than is the case with four-row barley. Good examples are the 1975 season (see first study) and the 1977 season. Oats will produce a good yield when the precipitation is high and temperatures are not too low. Rainfall must be of the order of 50 mm or higher for April as well as for May under the Westpolder conditions.

Panicum miliaceum

Millet was sown in 1973 for the first time in the experimental field. Because it was not known which variety of millet was best adapted to Northwestern European conditions and to the Westpolder especially, several varieties of different origin were sown. Of these varieties "La Plata" did better than the others.

In 6 years there were only two harvests, each with a limited yield: in 1975 the output was 5.5 times the input, and in 1976 some seed, a quarter of the input, was harvested. In the other years hardly any millet plants developed.

Panicum miliaceum was found by van Zeist in non-brackish surroundings (1974) in Vlaardingen-Broekpolder in a house site dating from the Iron Age (370 ± 70 B.C.). The experiments show that in brackish surroundings millet cannot be grown.

Triticum aestivum

Bread wheat was included in the program from 1973 onward. On some occasions a few plants developed producing a yield a few times greater than the input (1975, 1977). When the other cereals produced high yields the bread-wheat yield remained at 10-20% of the *Avena* and *Hordeum vulgare* production. For growth curves see fig. 7. The results demonstrate that bread wheat cannot have been grown on the unprotected salt marsh under conditions comparable with those of the Westpolder. The many coastal sites investigated by van Zeist (1974) do not show any bread wheat during prehistoric

times, apart from a find from Ouddorp on Goeree that could well have been imported.

Triticum spelta
Spelt did not give any results. There are no indications that spelt was grown in the coastal area.

Triticum dicoccum
Emmer wheat grown for three successive years only produced some plants in 1976 but the yield was very low, about half the input. Van Zeist mentions some emmer wheat for prehistoric Paddepoel (1974) and for pre-Roman Iron Age Middelstum (verb. comm.). On the unprotected salt marsh emmer wheat would not have been successful.

Brassica rapa
Rapeseed (summer rape, *Brassica rapa* = *Brassica campestris* forma *annua* according to Bengtsson, von Hosten & Lööf, 1972) proved a very satisfactory crop for the unprotected marsh. Growth curves are very similar to those of *Camelina sativa* (van Zeist *et al.*, 1976). Summer rape has a reasonable yield even under unfavourable conditions.

Van Zeist mentions *Brassica campestris* (rapa) for 8 out of 10 prehistoric finds in the Dutch coastal area.

The relatively short vegetation period of this plant and its immunity to certain changes in local conditions make it a very reliable crop (fig. 8).

5. GROWTH CURVES

In the first article on this subject (van Zeist *et al.*, 1976) growth curves were shown for *Camelina sativa* (not included in the last three years of the experiment), *Linum usitatissimum*, *Avena sativa* and *Hordeum*. In the growth curves the average height of the crop was plotted against time. It must be stressed that such a curve does not necessarily give any information about the yield. Even if a few seeds germinate on a plot, it is still possible to draw a growth curve. If these plants die before the harvest there is no yield at all, but there is still a growth curve. On the other hand the growth curve does say something about the state of health of the crop and this state is often also an indication of the productivity.

The curves (figs. 4-8) are based on information obtained during the last three years and are shown for three purposes. One series included curves not presented in the first study, *viz. Vicia faba* var. *minor* (fig. 5), *Brassica rapa* (fig. 8) and *Triticum aestivum* (fig. 7). Secondly, curves are shown which compare the growth behaviour of two different types of the same crop, *viz.* white and blue varieties of flax and the two-row and four-row breeds of barley. Finally the difference between the A and B plots is demonstrated.

The growth curves of blue- and white-flowered flax run parallel, there being in general a small advantage for the white-flowered variety (fig. 4). The growth curves for the seasons 1976-1978 compare well with those of the preceding years.

Van Zeist *et al.* (1976) point out the similarity of the behaviour of *Vicia faba* var. *minor* and oats and barley: either a steeply rising curve during June and July or a completely flat curve, running horizontal for both months. This clearly demonstrates the difference in production, these two curves indicating either a good crop or a complete failure (due to germination problems) accordingly.

In fig. 5 the growth curves for *Vicia faba* var. *minor* are shown for the three seasons and moreover for both plots, the A-plot being closer to the sea and the B-plot sheltered by the A-plot. Especially when the plot has a low number (fig. 2) it is one of those most exposed to sea wind. With the aid of these separate growth curves an attempt has been made to indicate the sensitivity of a crop to the micro-habitat of a sandy ridge in the salt marsh. Not every square metre of the arable area is equally suitable for optimum crop performance.

The differences in development and yield of two-row and four-row barley have already been discussed in this study. Information on the absolute size can be derived from the growth curves. The *Hordeum vulgare* curve rises much more steeply and at an earlier point in time than the *Hordeum distichum* curve (fig. 6). Not only do the plants develop more rapidly, they also attain a much greater height.

Bread wheat has a growth curve (fig. 7) which resembles that of two-row barley. Curves do not rise steeply but tend to run rather smoothly. Bread wheat is also comparable with two-row barley in terms of production or lack of yield.

The growth curve of *Brassica rapa* (fig. 8) shows the same character as the other cruciferous oil plant *Camelina sativa*. The growth curves run parallel with a steep curve in June demonstrating a relatively short growing season. The similarity in the growth curves demonstrates that summer rape is not easily influenced by external factors.

6. GENERAL REMARKS

The experiments carried out during the last three years give us supplementary information on the possibility of raising crops on unprotected salt marsh during the prehistoric and early historical period rather broadly described as the *terpen* period. In 1976 the results were compared with the results from Körber-Grohne's experiments at Cappelersiel (1976, pp. 209-231). Körber-Grohne concluded that *Camelina sativa* was the crop most resistant to salt and wind, followed by *Hordeum vulgare*, *Vicia faba* var. *minor* and *Linum usitatissimum*. Van Zeist *et al.* share her opinion on *Camelina* but think that *Hordeum* is more sensitive than *Linum*. In the first part of the experiment *Hordeum distichum* was used twice instead of *Hordeum vulgare*, as seed of summer-sown *Hordeum vulgare* was sometimes difficult to obtain (at the moment four-row summer-barley is not grown on an economic scale in the Netherlands). This resulted in confusion of the yield weights and the growth curves. After planting four-row barley for another three years (1976-1978) it seemed to be a more reliable crop than was thought at first.

Van Zeist (1974) identified finds of barley from prehistoric times in the Dutch coastal area as belonging to *Hordeum vulgare*. This fact together with the results from the agricultural experiment make it clear that *Hordeum distichum* is not so well adapted to the brackish surroundings of the coastal lowlands. During the *terpen* period four-row barley would have guaranteed a moderate to reasonable yield.

From table 2 it can be seen that *Linum* does not show so much variation in productivity as *Vicia faba* var. *minor*, but that the Celtic bean can have a very high production as well as complete failures. It should therefore still have been an economically important crop at that time.

Considering all the problems that a prehistoric *terpen* farmer could encounter, the moment at which a problem arose was very crucial. Thus a flood in July would have damaged flax more than the Celtic bean. Had the flood taken place in April during or just before sprouting then possibly neither flax nor beans would have survived.

When we consider the crops used in the experiment we can state that under certain conditions *Hordeum vulgare*, *Avena fatua*, *Camelina sativa*, *Brassica campestris*, *Vicia faba* var. *minor* and *Linum usitatissimum* were grown or could have been grown by farmers who inhabited the unprotected salt marshes along the coast. Crops like *Hordeum distichum*, *Triticum aestivum*, *Triticum spelta*, *Triticum dicoccum* and *Panicum miliaceum* were quite likely less suitable or unfit for brackish conditions. If they were grown in the unprotected area it must have been quite far from where the influence of the sea prevailed.

The experimental field at Westpolder is situated where conditions are rather extreme. One must assume that the *terpen* farmers met with fewer difficulties than we did. It is nevertheless remarkable that within a distance of a few metres differences within one crop are obvious. This must partly be due to exposure to the northwestern winds coming from over the sea, and partly also because of differences in composition of the ridge. The northern part of the ridge is situated closest to the sea and there most of the sand is deposited. Further from the sea the soil contains more clay. The crops do best on a mixture of sand and clay. The purer the sand the more severe are dry periods which also cause an increase in relative salt content. On pure clay (see the results of such a field, described in van Zeist *et al.*, 1976) the salt brought in by the sea during the winter is not easily washed out in the spring. Fields suitable for farming were relatively scarce during the *terpen* period as the farmers could only use part of the higher ridges along the coast and alongside streams. On the other hand the original *kwelder* (marsh) area was several kilometres wide, with the sea at some distance. Thus farming conditions were not too unfavourable.

7. REFERENCES

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