SOME ECOLOGICAL OBSERVATIONS ON CALTHA PALUSTRIS L.

(Mededeeling No. 34 der Zuiderzee-Commissie)

by

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The closure of the former Zuiderzee, causing a freshening of its water, was expected to induce similar changes in some of the surrounding regions. Consequently the distribution of several plants would be likely to alter gradually. As Caltha palustris is known to be one of the species, susceptible to salinity, the Zuiderzee-committee of the Netherlands Botanical Society, added to her program an investigation of its distribution in the regions in question and it was felt necessary to obtain ecological data concerning this plant.

According to the scheme just mentioned, the knowledge of the behaviour of the plant towards brackish water was considered to be most important. The investigation being in a preliminary stage, it did not yet reach so far as to include ionic antagonism, but only chlorinity was taken into account. Although my departure put an end to the experiments before they had reached final accomplishment, I was asked to summarize the results hitherto obtained.

In the first trial potcultures were used which were of course sheltered from rainfall. Though in this method the conditions, in which the plants grew are less known and controllable than with nutrient solutions, they are better comparable with those in natural state.

This experiment lasted from the 4th of March 1932 up to June 13th 1933. A survey of the arrangement is shown in fig. 2 and 6. The pots were placed in flat basins containing brackish water of different strength, the influence of which on the plants was to be examined. It was the aim to keep the level as well as the salinity of the soil moisture in the pots as constant as

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possible. When the waterlevel in the basin would be lowered by the evaporation which consequently would augment the concentration of the salts, the latter was controlled automatically, the freshwater in the bottle (which was closed at its top) flowing down into the basin. The level could be fixed, by turning the crooked tube in the lower opening of the bottle.

The variations, which occured in spite of these precautions, amounted to circa 2 cm, which may have caused errors of 10%. Care should be taken, that the bottles do not contain much air, as fluctuations of the temperature would force a nuisible ascent of the waterlevel in the basin. It is obvious, that the concentration of the brackwater would have been much more constant, if deep basins would have been used, but these were not at my disposal.

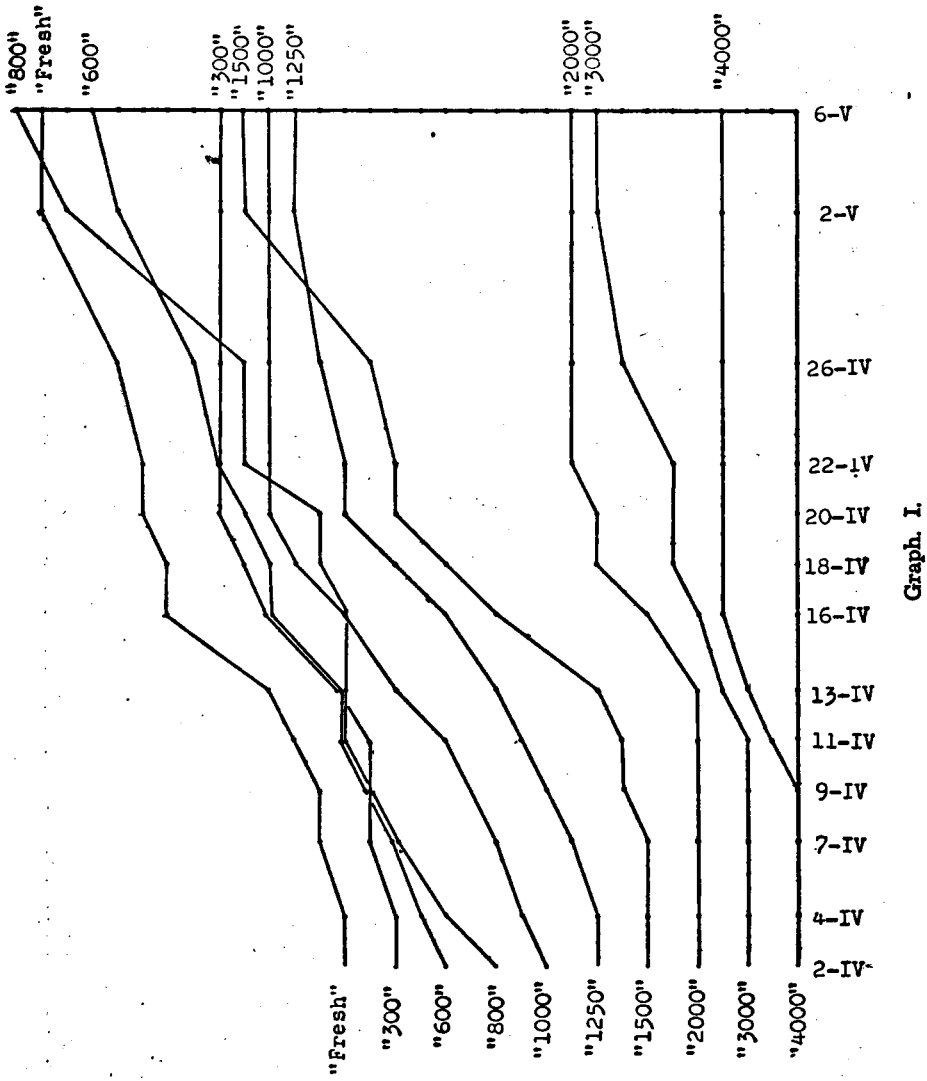
One of the greatest troubles of this arrangement of the experiments was the accumulation of salts in the upper soil-strata, caused by the evaporation. This source of errors however, was abolished to some extent by pouring on each of the pots every one or two days 100 cm^3 of brackish water, taken from their basin after stirring. The constancy of the salinity in the pots was tested several times by squeezing out a sample of the soil, and titrating the trickling liquid with $AgNO_3$ *). Though the results were rather unsatisfactory, it was a lucky circumstance that the set of pots, that appeared to be most important, was at the same time the most constant one. Its soil moisture was intended to certain 2000 mgr. Cl' per Liter. The salinity tests procured the following data:

22 nd	of	April	1932	1900	mgr.	Cl'	p. Liter.
18 th	of	May	1932	2500	„	„	„ „
10 th	of	Oct.	1932	2150	„	„	„ „
2 nd	of	March	1933	1950	„	„	„ „
15 th	of	May	1933	3360	„	„	„ „

This seems to reveal, that the concentration had not fallen down far below 2000.

Fig. 2 shows a survey of the whole series of potcultures. It was the intention, that the soilmoisture in the pots, standing in the different basins should contain respectively 4000, 3000, 2000, 1500, 1250, 1000, 800, 600 and 300 mgr. Cl^- per Liter, whereas one set was provided with fresh water. Because of the unsatisfactory control of the salinities, it seems advisable not to attach much weight to these numerical values, and only to indicate

*) I am much indebted to Mrs. Wibaut for the titrations that were carried out in her laboratory.


"800"
"Fresh"
"600"
"300"
"1500"
"1000"
"1250"
"2000"
"3000"
"4000"
6-V
2-V
26-IV
22-IV
20-IV
18-IV
16-IV
13-IV
11-IV
9-IV
7-IV
4-IV
2-IV
"Fresh"
"300"
"600"
"800"
"1000"
"1250"
"1500"
"2000"
"3000"
"4000"

Graph. I.

the pots by their intended concentration: "1000" "3000" and so on. Notwithstanding this, stress should be laid on the fact, that the whole constantly formed a descending series from brackish to fresh water, so that the effect of brackish water on Caltha palustris could be studied at various grades of salinity.

All the plants were taken from the same swampy meadow along the "Mooie Nel" near Haarlem, so that they had grown under conditions that are likely to have been somewhat the same. Yet they were rather unequal in size, and therefore more or less unsuitable for experiments that ought to have undergone statistical treatment.

Among the flowering plants, two distinct types could be discerned (fig. 3 and 4). The petals of one type were greenish-yellow, somewhat tapering towards the top, while those of the other were rather circular, and yolkcoloured. Though this discernment was confirmed in the meadow near the "Mooie Nel" it seems still doubtful whether this would be the case elsewhere. Concerning its resistance to brackish water, no obvious difference could be detected between the two types, but from another point of view they will be mentioned furtheron.

As Caltha was said to grow only in soils rich in organic matter, two different soil types were tried. One of the types was peat-soil from a moor near Halfweg, being so rich in organic matter that it lost on ignition as much as 48,2% of its dry weight. The other was heavy silt from the IJ-polder (near Hembrug) being rather poor in "humus"; on heating the loss amounted only to 9,7%. In relation to the behaviour of Caltha palustris towards brackish water, however, no striking facts could be stated and so the effect of different soil types upon the behaviour of the plant will be discussed in an other connection.

During the first summer, flowers have been produced in all of the tried salinities, though the vitality had markedly decreased in the more brackish soils. The flowers were counted several times and the statements are recorded in the following table.

Taking the numbers from the two soil-types together, and plotting them in a graph against time, the effect of salinity may be seen at once (Graph I).

From fresh to "1500" the plants seemed to flourish quite normally. In "2000" the number of flowers was reduced and the growth of the plants somewhat stunted, whereas in "3000" and "4000" they were really dwarfish and the few flowers shrivelled up soon after opening.

TABLE I.

		2-IV-1932	4-IV-1932	7-IV-1932	9-IV-1932	11-IV-1932	13-IV-1932	16-IV-1932	18-IV-1932	20-IV-1932	22-IV-1932	26-IV-1932	2- V-1932	6- V-1932
"Fresh"	Peat	0	0	0	0	0	1	1	1	2	2	3	5	5
	Silt	0	0	1	1	2	2	6	6	6	6	6	7	7
"300"	Peat	0	0	1	1	1	2	4	5	5	5	5	5	5
	Silt	0	0	0	0	0	0	1	1	2	2	2	2	2
"600"	Peat	0	0	0	0	0	0	2	2	3	4	5	8	8
	Silt	0	1	2	3	4	4	5	5	5	5	5	5	6
"800"	Peat	0	1	3	3	4	4	4	4	4	4	4	4	6
	Silt	0	1	1	2	2	2	2	3	5	6	6	13	13
"1000"	Peat	0	0	0	1	1	3	4	6	7	7	7	7	7
	Silt	0	1	2	2	3	3	4	4	4	4	4	4	4
"1250"	Peat	0	0	1	2	3	3	3	3	3	3	3	3	3
	Silt	0	0	0	0	0	1	3	5	7	7	8	9	9
"1500"	Peat	0	0	0	1	1	2	4	5	5	5	5	6	6
	Silt	0	0	0	0	0	0	2	3	5	5	6	10	10
"2000"	Peat	0	0	0	0	0	0	1	1	1	2	2	2	2
	Silt	0	0	0	0	0	0	1	3	3	3	3	3	3
"3000"	Peat	0	0	0	0	0	1	2	3	3	3	3	4	4
	Silt	0	0	0	0	0	0	0	0	0	0	2	2	2
"4000"	Peat	0	0	0	0	0	1	1	1	1	1	1	1	1
	Silt	0	0	0	0	1	1	2	2	2	2	2	2	2

After hibernation the experiment was continued with "fresh", "600", "1000", "1500", "2000", "3000" and "4000". From "fresh" to "1500" the plants developed normally; in "2000" they were stunted, but still able to produce flowers and even mature seeds; "3000" scarecely continued vegetative growth and "4000" soon succumbed. "Fresh", "2000", "3000" and "4000" were photographed on 10th of April '33 (see figs. 7, 8, 9 and 10 respectively).

Though these results may not be quite convincing in all details, they show at any rate, that the viability of full grown Caltha palustris diminishes only slowly with increasing salinity. Hence the objections already discussed, do not render the data quite worthless. Moreover some other observations appeared to be in accordance with the results hitherto described. Consequently, as a provisional result it may be borne in mind, that the plants may endure a salinity of 2000 mgr. Cl^- per Liter, for at least two seasons, and are still able to propagate under this condition.

Because the insufficient control of the salinity was the principal disadvantage of the potcultures, it was endeavoured to check these statements with the aid of another method, free from this drawback. For this purpose a series of watercultures

was started, as these do not offer any incertitude as to the constancy of the salinities. Fullgrown plants were simply put in cylindric jars, containing the various dilutions of seawater. This arrangement, however, was less suitable for tests in the long run, as it placed the plants in unfavourable condition. Though this series, too, cannot be considered to be perfect, it still procured some appreciable supplementary data.

March 23rd 1933 three full grown plants were exposed to each of the concentrations: fresh, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000 and 10000. Some silt was added to the dilutions, which were stirred now and then.

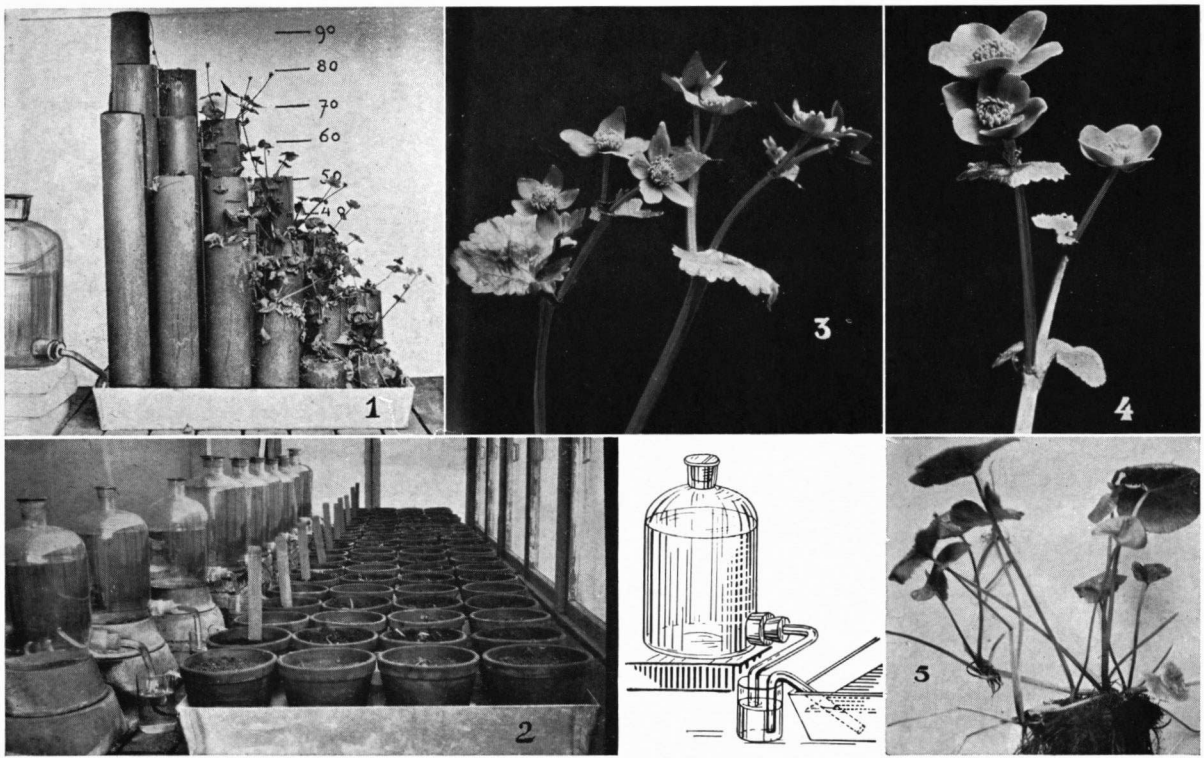
The solutions that contained 5000 mgr. Cl^- per Liter or more, soon showed signs of putrefaction, as the roottissue of Caltha was apparently not able to withstand this concentration; 4000 was also putrified, though in a slight degree. In spite of this obvious decomposition of their roots, and the dying off of most of their leaves, the plants continued to produce some dwarfish leaves for about four months. This resistance of the full grown plants troubled the results in an inconvenient way because it was now difficult to judge, whether a plant would succumb or not. More definite results could therefore be expected from experiments with seedlings. These will however be discussed in connection with germination.

In the solutions containing 3000 mgr. Cl^- per Liter or less, the roots did not show any putrefaction, but as the conditions appeared to be rather unfavourable, these cultures could not be continued during next season. So far as comparison was possible, the behaviour of the plants in watercultures was rather in accordance with that in the potcultures.

The observations hitherto summarized only regarded the resisting power against salinity, but it was also the intention to look for changes that the plants might have undergone, as a result of their having been placed in the brackish media.

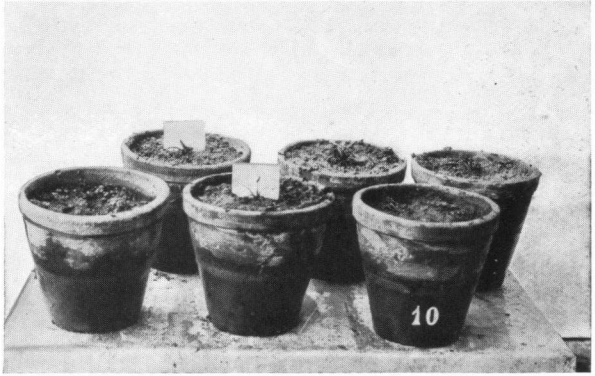
April 22nd 1932, some material was gathered from the potcultures for morphological examination. Crossections of leaves and pedicles, however, did not reveal any of the conspicuous changes, as are known from some halophytes. Further a number of leaves was specially tested for succulency; surface, fresh weight and dry weight were determined for each of them (see table II). From these measurements, fresh and dry weight per cm^2 were calculated as we might expect, that these statistics would increase if the leaves grew succulent.

As may be seen in the table, these data do not allow us to



EXPLANATION OF FIGURES.

1. Arrangement to test of drainage in different soils (16-IV-1934). 2. Survey of potcultures at the beginning of the experiment (4-III-1932). 3. & 4. Two different flowertypes of Caltha palustris. Size x ½ (19-IV-1932). 5. Root formation near lowest stalk-leaf. (15-VII-1933). 6. Arrangement, controlling waterlevel in the basin.



7. Potcultures "fresh" (10-IV-1933).
9. „ "3000" „

8. Potcultures "2000" (10-IV-1933).
10. „ "4000" „

TABLE II.

		I Surface in cm²	II Fresh weight in mgr.	III Dry weight in mgr.	II/I Fresh weight per cm²	III/I Dry weight per cm²
"Fresh"	Peat	13,0	265	48	20	3,7
	Silt	11,9	285	55	24	4,6
	Silt	14,8	315	62	21	4,3
"300"	Peat	23,7	535	92	23	3,9
	Peat	11,0	235	54	21	4,9
	Silt	11,0	270	44	25	4,0
"600"	Peat	11,9	250	48	21	4,0
	Peat	11,2	210	33	19	2,9
	Silt	20,6	445	67	22	3,3
"800"	Peat	19,7	445	73	24	3,7
	Silt	16,5	373	70	23	4,2
	Silt	17,6	405	71	23	4,0
"1000"	Silt	19,4	420	77	22	4,0
	Silt	20,0	440	90	22	4,5
	Silt	14,8	380	67	26	4,5
"1250"	Peat	13,5	275	55	20	4,1
	Silt	9,9	255	45	26	4,5
	Silt	10,1	230	43	23	4,3
"1500"	Peat	16,0	350	59	22	3,7
	Silt	9,4	245	42	26	4,5
	Silt	12,3	260	44	21	3,6
"2000"	Peat	18,4	440	69	24	3,7
	Peat	7,7	195	33	25	4,3
	Silt	12,8	255	46	20	3,6
"3000"	Peat	23,0	720	107	31	4,7
	Silt	17,7	445	67	25	3,8
"4000"	Peat	7,9	165	31	21	3,9
	Peat	9,5	295	31	31	3,3

say that the plants grew succulent though it must be stated, as a disadvantageous circumstance, that only few leaves from the more brackish plants were available.

In order to obtain some data concerning a possible change of chemical composition consequent on the increased soil-salinity, a number of plants from the potcultures was destined for chemical analysis. Since the overground parts of the plants from the higher concentrations were rather badly developed these were less suitable to be compared with those of normal plants. For that reason the roots were kept apart for the purpose of Cl^--analysis.

On account of the variability of the material, it was the

obvious way to investigate the rootsystems individually, and therefore it was necessary to resource to a micro-analytical method. For these analyses I am much indebted to Dr. A. W. H. VAN HERK, who carefully carried them out after the method of van SLYKE and SENDROY (Quantitative Clinical Chemistry Volume II).

In short the procedure was performed as follows. The roots were first thoroughly washed and dried, then ground in a mortar and sieved. The organic matter of the weighed sample

The data, thus obtained, are given in the following table.

plant	mgr. dry weight of sample	mgr. Cl— present in sample	mgr. Cl— per 100 mgr. dry weight: single determination	mean for each plant	mean of each group
fresh					
I	375,73	1,121	0,298	0,298	
	450,14	1,341	0,298		
II	393,67	1,220	0,310	0,310	
	548,67	1,703	0,311		
III	354,58	1,040	0,293	0,295	0,308
	466,83	1,387	0,297		
IV	389,07	0,997	0,256	0,258	
	276,58	0,716	0,259		
V	261,39	0,914	0,350	0,350	
VI	263,98	0,884	0,335	0,336	
	320,09	1,077	0,336		
"2000"					
I	408,81	4,830	1,182	1,188	
	285,84	3,412	1,194		
II	265,88	2,910	1,095	1,106	
	284,98	3,179	1,116		
III	290,43	2,961	1,019	1,018	
	344,82	3,503	1,016		1,260
IV	297,20	5,136	1,728	1,726	
	209,69	3,612	1,723		
"3000"					
I	236,34	1,524	0,645	0,645	
	255,52	1,649	0,645		
II	421,17	4,778	1,135	1,130	
	454,16	5,108	1,125		
III	391,35	4,136	1,057	1,057	0,972
IV	339,43	2,964	0,873	0,873	
V	296,67	3,520	1,186		
	228,35	2,703	1,184	1,185	
VI	448,10	4,221	0,942	0,942	
possible error	3 units of last decimal	6 units of last decimal			

was destructed by heating with nitric acid under addition of $KMnO_4$. The Cl^-, present in the sample, was precipitated by a known quantity of $AgNO_3$. The excess of $AgNO_3$ was titrated back with an alcoholic solution of KCNS, with ferric alum as indicator. The alcohol accentuated the change of colour caused by the formation of $Fe(CNS)_3$. The comparison with a blank titration yielded the quantity of KCNS, that agrees with the amount of Cl^-, present in the sample.

As may be seen from the table it is evident, that the roots from the saline soils are showing an increased chloride content.

The data concerning the resistance of the fullgrown plants against brackish water, were affirmed by observations on germination and behaviour of seedlings.

In 1931 seeds were collected from plants in the meadows and kept in dry storage up to April 1932, when they were sown in the potcultures. Much to my disappointment germination almost failed to take place, the amount being estimated at less than 1%. Fortunately, however, one of the very few germinating seeds occurred in "2000". The seedlings did not succumb here, but hibernated and kept growing during the next season. In fig. 8 it is shown in a pretty good condition in the little pot on the left side. In this it rather agrees with the behaviour of the fullgrown plants. In the meantime the extreme difficulty of germinating was a mystery, that was solved by chance.

On account of the distribution of Caltha in some meadows, BETTINK *) assumed that during the winter there couldn't be any floating seeds on the water. In order to test this assertion, I put some fresh seeds into a bottle of water. The seeds kept floating only for about ten days, but then they sank to the bottom. Such sunken seeds keep the property of floating like fattish particles when brought up to the surface by stirring. Meanwhile the sunken seeds germinated promptly. It appeared that such an easy germination only happened when the seeds were still green or scarcely brown, and within a week's time their ability to germinate vanished almost entirely when kept dry. This information offered the possibility of involving germination in the investigation.

At the time however, fresh seeds were no longer obtainable, but plenty of seedlings were at hand. So these were used for water cultures in fresh, 2000, 3000, 4000 and 5000 mgr. Cl per Liter; at least 20 seedlings being placed in each of the dilutions.

In 2000 the plants grew somewhat poorer than in fresh; in

*) Correspondentieblaadje Zuiderzee-onderzoek, Vol. III, No. 1, p. 19, 1933.

3000 the root development was badly abused and besides the cotyles only one little leaf was formed; in 4000 the rootlets turned blackish and in 5000 the seedlings soon succumbed. Again, the conditions in the water cultures did not allow to continue the trials for a long time, as the roots in the brackish waters were overgrown by Cyanophyceae.

The following year, about the first of June 1933, fresh seeds were collected in order to examine germination. Samples of about 100 seeds were put into bottles and exposed to fresh water, 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000 and 10000 mgr. Cl per Liter.

In attending to these germination trials, care must be taken that after handling the bottles, no seeds adhere to the glass above the liquid, for if they do, they would after some time be moistened by condensed water. As this is of course fresh, it would make the grains germinate as in a fresh water test.

In these trials no countings were undertaken because they rather concerned the way of development than the number of survivors. Moreover the samples were even likely to contain different quantities of deaf seeds. This was the consequence of the impossibility of starting the whole series at the same time after harvesting only once; as a rule only a few plants were at hand, and the rapid decrease of the germinative power prevented me from storing the seeds before using them for experiments.

It appeared, that with increasing salinity, development of the plants stopped sooner and even germination was more and more checked. In 1000 and 2000 the vitality of the seedlings was somewhat less than in fresh water. In 3000 and 4000 they were only scarcely able to develop the cotyles. The higher the concentrations, the less the vital functions could exert themselves, so that in the higher concentrations only some grains would burst indicating a last vital effort. In 10000 at last, the seeds did not show any changes at all, but when they were replaced in fresh water next year, May 1934, they germinated as promptly as if they had been harvested only recently. In this strength the brackish water had apparently acted as a preservative.

This curious fact may have some importance in the geography of this species, for after an overflowing with water of sufficient salinity to kill all the Caltha plants, seeds from the same spot might secure continuity.

Perhaps this information may be of some practical value for

seed storage, as it might be the case that the keeping properties of some commercial seeds would also be improved by wet storage, when germination would thus be checked and drying out prevented. It is not likely however, that the above will be applicable to many species.

Unfortunately I was not in a situation to repeat the experiment and to try it also with undiluted sea water or even with stronger brines.

Among the samples of this series, there were some that did not show any vitality for a long time, though this could not be expected on account of their salinities. Contrary to the other bottles, these smelled somewhat musty and only when algal growth succeeded the moulds, germination occurred. Apparently the oxygen condition determined germination in these bottles. Perhaps this evidence could likewise be utilized in developing another method of wet seed storage.

Besides the described properties of the seeds, some other observations could be made on reproduction in Caltha palustris.

To all appearance Caltha is self-sterile to a rather high degree. This statement is founded on the results of 10 self-pollinations, 4 of which remained quite sterile, while the others only produced 5 seeds or less. Most of the crossings, however, produced considerable yields. Further work will have to be done to clear up this matter.

Vegetative reproduction was also observed. In once found a specimen in my garden surrounded by some young plants. As it was a petalodious variety with absolutely infertile flowers, it must have been a case of vegetative reproduction and on closer examination it appeared to be brought about by root formation near the insertion of the lowest stalk-leaf (fig. 5). Later on I could make the same observations on wild plants in the meadows.

The influence of the different soils remains to be discussed now.

In the description of the pot cultures, the use of peat as well as of silt has already been mentioned. The loss of dry weight on ignition of the peat was determined to be 48,2% and of the silt 9,7%. In this connection it is perhaps more important to state that the peat lost more than 70% of its volume when ignited, while the volume of the silt did not diminish at all. Caltha was expected to thrive better in peat but surveying the figures in table I, we cannot affirm this nor did the peat-plants look better in any other respect. Admittedly in this experiment

the common watersupply may have effaced some eventual differences, but in the garden as well as in the meadows I noticed that Caltha is able to grow very well in silt.

As marshes are known to offer optimal conditions to Caltha it was obvious to examine the effect of drainage in the principal soils of the explored areas, namely peat, silt and sand *). The arrangement of this experiment is shown in fig. 1. Bottomless jars of different heights were placed in a basin with constant water level. The soil in the jar was thoroughly moistened with fresh water at the beginning of the trial (24-III-1933); the plants were then put into it and sheltered from rainfall. Hence the fresh water in the bottles was the only watersupply. After the drying up of the upper strata had caused some shrinkage, the heights (in cm) of the soil surfaces above the water level in the basin approximately were:

peat	85	75	60	45	30	15
silt	75	60	45	30	15	5
sand	60	45	30	15	5	

Indicating a living plant by o and a dead one by +, the state on 1-VII-1933 is as follows

	85	75	60	45	30	15	5
peat	+	0	0	0	0	0	
silt		+	+	0	0	0	0
sand			+	0	0	0	0

and the state on 16-IV-1934 (fig. 1) by

	85	75	60	45	30	15	5
peat	+	0	0	0	0	0	
silt		+	+	0	0	0	0
sand			+	+	0	0	0

Under shelter the maximal heights above the waterlevel in the soil where Caltha is able to grow, appeared to be 30 cm in sand, 45 cm in silt and 75 cm in peat. Though this trial ought to have been repeated on a larger scale and the conditions in the experiment are not realized in the field, these provisional results still point to the fact, that a low water table during a dry season will have the most injurious effect in sandy soils, less in silt soils and least of all in peat soils. This is due to the higher watercapacity and the higher rising of moisture in peat and silt than in sand. Perhaps this may be a co-operating cause of the notable preference for peat, that may be stated in some regions.

*) of marine origin.

The question arises, how far the results of our laboratory-experiments can be confirmed by observations in the field. We mean especially the data concerning the resistance to salinity, for one is inclined to doubt whether the situations in the experiments are really comparable to natural conditions. The objection could be made, that in the experiments there was no competition of other plants, that is to say of other phanerogams; as for mosses, algae, moulds and bacteria, these were by no means excluded.

Some evidence may be obtained by combining available data of salinity and of the distribution of Caltha in the explored area.

For the province of North-Holland we may use both the publications of Mrs. N. L. WIBAUT-ISEBREE MOENS and the writer's atlas of the distribution of Caltha. In the investigation of Mrs. WIBAUT and co-workers, water samples were taken twice or thrice a year of some 250 fixed places from canals and ditches. Chlorinities were determined at the laboratory by titration. Number 66 of the series (Oude Nie, Sluisbuurt near Akersloot) is the most interesting one in this connection; close to the spot where I used to take the sample there was a bright specimen of Caltha. As it grew amidst the reeds along the canal, its roots were likely to be permanently in contact with water of the same chlorinity as the sample. In May 1929 I first found the plant which was then in full flourish. In following years I saw it flowering again while the chlorinity of the canal took the following course:

29- IV-1930	4150	mgr.	Cl^-	per	liter.
1-VII-1930	6700	„	„	„	„
20- X-1930	1800	„	„	„	„
15- IV-1931	1700	„	„	„	„
28- VI-1931	2220	„	„	„	„
27- X-1931	3500	„	„	„	„
28/29- IV-1932	2260	„	„	„	„
12- X-1932	810	„	„	„	„
27- IV-1933	1150	„	„	„	„
21- IX-1933	3700	„	„	„	„
30- IV-1934	1470	„	„	„	„
2- XI-1934	2250	„	„	„	„

This is the most striking example of resistance I met with, and it rather agrees with the conception that Caltha could withstand 2000 mgr. Cl^- per liter for a long time and occasional exposals to higher concentrations.

KOOPMANS-FORSTMANN & KOOPMANS, who examined the distribution of Caltha in Friesland, obtained results that seemed to

be contrary to ours, as they did not find Caltha growing anywhere along water containing more than 600 mgr. Cl- per liter.

Now the investigation in North-Holland has revealed that the salinity of the canals may show a considerable variance in the course of a year. During summer it will usually increase and the rains of winter will freshen the waters again, so that one may expect the lowest salinities in spring. Some years before DE WAAL had shown that also in Friesland such variations take place. Now KOOPMANS had taken the water samples only once, in May 1929, when the waters of Friesland happened to be exceedingly fresh, which may be seen in the next table. DE WAAL's figures indicating salinity are converted here into values of chlorinity (mgr. Cl^- per liter):

	Tjeukemeer	Sneekermeer	Koevorde
11- X-1921	1314	729	1488
19- X-1921		862	
28- III-1922	830	444	792
13- III-1923			377
4- IX-1924	349	287	566
5- VII-1925		613	
2-VIII-1925		595	
6- IX-1925		692	
4- X-1925		613	
11- V-1929	210	300	400
V-1929	*220*	*300*	*400*
Koopmans	*Caltha present*	*Caltha present*	*Caltha present*

This seems to bring the results of the investigations in Friesland more in accordance with those in North-Holland.

The writer wishes to express his thanks to Prof. Dr. Th. WEEVERS, for the hospitality I met with in his laboratory, and to Dr. A. W. H. VAN HERK for his kindness of carrying out the micro-Cl^--analyses.

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*) Deposed in the library of the Netherlands Botanical Society (Colonial Institute). The data are also kept in the archives of the Society's Zuiderzeecommission.