FRUCTIFICATION IN DUTCH MAIANTHEMUM BIFOLIUM POPULATIONS

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SUMMARY

Aspects of fructification in *Maianthemum bifolium* were studied, mainly in natural populations in The Netherlands, but also in additional laboratory experiments. C. 15% of the plants were found to produce flowers. On an average 25.1 ± 3.59 flowers and 2.7 ± 2.24 fruits were established per fruiting plant, and a mean of 1.2 fruits per flowering plant. It was ascertained that at soil pH ⩽ 4 generally more fruits were produced than at higher pH values. At a coverage of ⩾ 35%, a highly positive correlation was found to exist between the coverage percentage of undergrowth and the number of fruits produced. A presumed positive effect of the undergrowth via a raised air humidity on fruit production was affirmed by laboratory experiments. Syrphidae appeared to be the most important pollinating insects. However, insect pollination did not appear to be decisive for fruit production.

1. INTRODUCTION

The genus *Maianthemum* has a circumpolar distribution and comprises three closely related species: *M. bifolium, M. dilatatum* and *M. canadense* (for geographical and cytological data see *table 1*).

Morphological, ecological and geographical investigations of the genus were carried out by KAWANO et al. (1967, 1968a, 1968b, 1971a, 1971b) and SUZUKI et al. (1967); cytological investigations by KAWANO et al. (1967, 1971a), KUSANAGI & KAWANO (1975), SOKOLOVSKAYA (1961), SOKOLOVSKAYA & STRELKOVA (1960) and VALENTINE & HASSAN (1971). Variation in (re)production between *Maianthemum* populations was described by BOIŃSKA & NIENARTOWICZ (1978), FALIŃSKA (1979), SILVA (1978) and SILVA et al. (1982). The photosynthetic behaviour of *Maianthemum* was examined by KOYAMA & KAWANO (1973). Since none of the studies on reproductive biology elucidate the causes of differences in fruit yield between populations, we studied a series of *M. bifolium* populations in The Netherlands, and carried out some additional laboratory experiments.

2. METHODS

Forty-six populations were selected (see *fig. 1* for their topography), which were studied in 1982. Each population comprised from a few tens up to several thousands of flowering stems. In the present study each vegetative or flowering stem

is regarded as individual, because these shoots behave like independant entities in that they perform the productive and reproductive function independently from each other according to SILVA et al. (1982). KAWANO et al. (1968a) found that up to some tens of shoots may form together one specimen. Some of the examined populations were divided in two subpopulations. A homogeneous unit was chosen in all larger populations. When a unit contained more than 60 flowering *Maianthemum* plants, a sample was taken from it, as randomly as possible. The percentage of flowering plants (%f) and that of fruiting plants (% + b) were estimated. Per fruiting plant the number of flowers (N_f) and that of fruits (N_b) were determined by counting. Starting from these data the following values were calculated for each population: average number of flowers and fruits per fruiting plant (respectively $\overline{N}_f$ and $\overline{N}_b$), average number of fruits per flowering plant ($\overline{N}_{b \times \%}$) and mean percentage of flowers developing into fruits ($\overline{\%N}_{b/f}$). The chromosome number was studied by use of the squash-method as described in IETSWAART et al. (1983). Of each population a vegetation survey was made in the way as described previously (see IETSWAART et al. 1984). Syntaxa were named with the aid of WESTHOFF & DEN HELD (1969). A soil sample was taken from each population, of which the acidity (pH) was established with a liquid colour test and the amount of organic matter by incineration. A soil typification was carried out with the aid of "Atlas van Nederland" (ANON. 1977).

During the flowering period of the *Maianthemum* plants attention was paid to insects visiting the flowers. Identification was carried out with BARENDREGT (1978) and VAN DER GOOT (1981) for hoverfly species and DEN BOER (1977) for bumble-bees. To examine the effect of experimental pollination on fructification, additional pollination by hand was carried out in eleven populations in 1982 and in one population in 1983. The pollen was always taken from various parts of the same population. In addition, in 1984 a group of 35 plants was regularly pollinated by hand under laboratory conditions (air humidity 10–50%; slightly shading from daylight).

The presumed association of air humidity with fructification was investigated by keeping three groups of 60 plants under different air humidity conditions in the laboratory from May till October (air humidity respectively 10–50%,

Table 1. Distribution area (according to HULTÈN 1962), and chromosome numbers (according to VALENTINE 1976), of the three species discerned in the genus *Maianthemum*.

| species	distribution area	chromosome number
M. bifolium (L.) F. W. Schmidt	West Europe to Japan	2n = 36, and 64–70 near Vladivostok
M. dilatatum (Wood.) Nels. et Macbr. (syn. *M. kamtschaticum* Komarov)	western North America and north-eastern Asia, southwards to California and Japan respectively	2n = 36, and 54 in Kamtschatka
M. canadense Desf.	eastern North America, east of the Rocky Mountains	2n = 36, 54 and 72
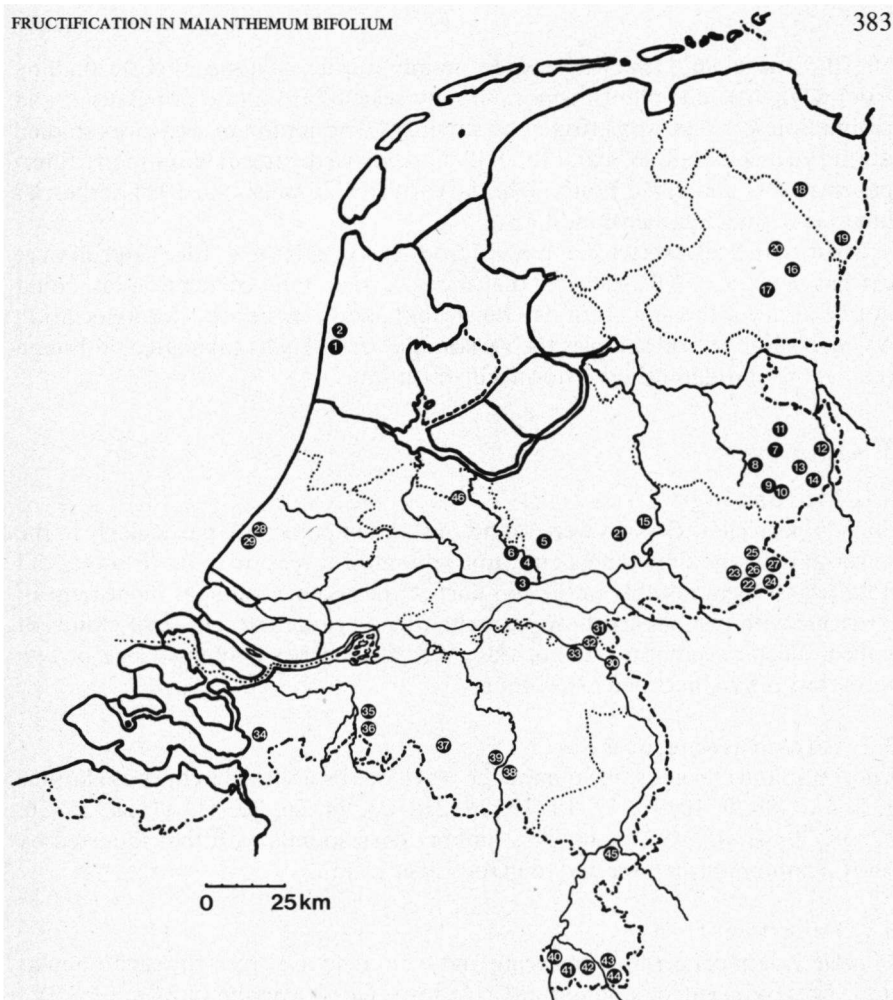
Fig. 1. Topography of the *Maianthemum bifolium* populations studied (for each population with the name of the municipal in brackets).
1 Verbrande Pan and 2 near De Franschman (Bergen); 3 Wageningse Berg (Wageningen); 4 Edese Bos, 5 near parking of Museum Kröller-Müller and 6 Roekelse Bos (Ede); 7 between Saasveld and Borne (Weerselo); 8 Deldeneresch near Lage Eschweg (Ambt-Delden); 9 near Bad Boekelo and 10 Weele (Enschede); 11 estate Het Everloo (Weerselo); 12 southern edge of De Lutte (Losser); 13 along Haveriet near Driene (partly Hengelo); 14 estate Den Hofmeyer (Enschede); 15 estate Den Bramel (Vorden); 16 northern part of Valtherbos (Odoorn); 17 near Klenckerveld (Oosterhesselen); 18 Metbroekbos (Vlagtwedde); 19 east of Ter Apel (Ter Apel); 20 a few km north of Odoorn (Odoorn); 21 along Kruisdijk (Vorden); 22 't Lintum, 23 Driemark, 24 Tuunterveld, 25 Bonnink, 26 Nieuw Esselink and 27 De Haar near Linkse Wooldseweg (Winterswijk); 28 estate Clingendael and 29 Haagse Bos ('s-Gravenhage); 30 Hoenderbergse Bos, 31 near Berg en Dal, 32 near Duivelsberg and 33 Wester Meerwijk (Groesbeek); 34 estate Lievensberg (Bergen op Zoom); 35 St. Annadreef near Ulvenhout (Nieuw-Ginneken) and 36 idem; 37 estate Ananinas Rust (Hilvarenbeek); 38 near Collse Molen and 39 Eckartse Bos (Eindhoven); 40 Bunderbos (Bunde); 41 Ravensbos and 42 Gerendal (Valkenburg-Houthem); 43 Kruisbos (Wittem); 44 Vijlenerbos (Vaals); 45 near Muningsboshof (St. Odiliënberg); 46 east margin of Wijde Blik near Kortenhoef ('s-Graveland).

50–70% and c. 96%, the fluctuations mainly during daytime; slightly shading from daylight). The plants were randomly selected from one population, and pollination was regularly effected by stirring. Germination of seeds was studied during two consecutive years. In 1982/83 seeds were stratified on moist filter-paper at 4 °C and 12/12 hours light/dark during six weeks. In 1984/85 berries hibernated under garden conditions.

Most statistical tests were borrowed from SOKAL & ROHLF (1981) and all were carried out at $\alpha = 0.05$. In cases that the Spearman rank correlation test could not be applied, the less accurate Olmstead-Tukey's corner test for association was used. For several samples the variance, $S^2 (n-1)$, was calculated, although these samples did not show a normal distribution.

3. RESULTS

3.1. Morphology
Shortly pedicellate flowers were found to stand in pairs and, particularly in the lower part of the flowering stems, not seldom in threes or fours. Flowers did not always open, notably in the top part of the raceme. A slight movement of a raceme with just opened flowers could already cause the release of clouds of pollen. Nectar secretion was not observed. The berries contained one or two seeds, less often three, and rarely four.

3.2. Chromosome number
The tetraploid chromosome number $2n = 36$ was established in the populations 1, 2, 4, 6, 8b, 9, 10, 13, 17, 18, 19, 20, 21a, 23, 24, 26, 30, 31, 33, 34, 35, 36, 37, 38, 39, 41, 43, 45 and 46. This number corresponds with that reported by several authors earlier referred to in the introduction.

3.3. Fructification
In *table 2* data concerning flowering and fruit-yield are given for each popula-tion. These data can be summarized as follows. On an average 15.2 (< 1–33.3)% of the plants flowered and of these 4.1 (0–12.5)% produced one or more fruits. The average number of flowers that produced a fruit varied from 0–26.4% with 10.1 as mean value. The mean number of flowers per fruiting plant varied from 18.9 $\pm$ 2.58 to 32.5 $\pm$ 3.95, with as mean 25.1 $\pm$ 3.59. The number of fruits per fruiting plant was on an average 2.7 $\pm$ 2.24 and this number converted in a value per flowering plant was 1.2. There is one observation on fluctuation in number of fruits in 2 successive years: in population 6 the average number of fruits per fruiting plant was 1.80 in 1982 and 4.32 in 1983.

3.4. Environment of the populations

3.4.1. Abiotic environment
In the surface soil layer the pH varied from 4.0–5.0(–5.5) and the percentage organic matter usually from 15–25% (values as low as 2% and up to 54% were

sometimes ascertained). Most populations were found on fine, sometimes coarse or gravelly, more or less loamy sand, some on slightly sandy loam, two populations on loess. Population no. 46 was found on a peaty soil which contained 74.3% water, a highly deviating ecological condition (see also 3.4.2).

3.4.2. Vegetation
Most of the vegetation surveyed in the populations belonged to Quercion robori-petraeae associations, a few to Alno-Padion ones, and fifteen to intermediates

Table 2. Several aspects of flower and fruit production for the 46 *Maianthemum* populations (1): percentage of flowering plants (2), percentage of flowering plants forming fruits (3), sample size for following categories (4), percentage of flowers developing into fruits (5), mean number of flowers per fruiting plant (6), mean number of fruits per fruiting plant (7), and mean number of fruits per flowering plant (8). With 6 and 7 also the variances (n − 1) are given. Dash means no observation(s).

(1) popula-tion	(2) %f	(3) % + b	(4) n	(5) %$N_{b/f}$	(6) N_f	(7) N_b	(8) $N_{b \times \%}$
1	14.0	1.0	—	—	—	—	—
2	1.0	0	—	0	—	0	0
3a	16.7	50.0	23	13.2	27.7 ± 4.31	3.17 ± 2.39	1.6
3b	12.5	4.0	—	—	—	—	—
4	12.5	50.0	75	—	—	2.97 ± 2.57	1.5
5a	7.7	80.0	32	24.5	23.1 ± 4.38	5.50 ± 3.83	4.4
5b	16.7	—	—	—	—	—	—
6a	12.5	50.0	20	7.3	24.4 ± 4.11	1.80 ± 1.06	0.9
7a	4.8	4.8 1.0	—	—	—	—	—
7b	—	44.4	20	15.5	21.5 ± 2.46	3.30 ± 2.23	1.5
8a	20.0	16.7	102	4.9	32.5 ± 3.95	1.66 ± 1.22	0.3
8b	—	85.7	133	—	—	3.44 ± 3.91	2.9
9	6.3	0	—	0	—	0	0
10	9.1	—	12	16.8	28.8 ± 4.73	4.75 ± 3.44	—
11	6.3	50.0	20	14.3	19.8 ± 3.16	2.85 ± 1.46	1.5
12	16.7	50.0	20	16.0	31.9 ± 4.98	5.20 ± 3.58	2.6
13	—	50.0	20	16.8	24.3 ± 3.39	4.0 ± 2.62	2.0
14	8.3	80.0	20	18.0	28.9 ± 6.66	5.25 ± 3.18	4.3
15	14.3	50.0	20	10.9	26.3 ± 2.58	2.95 ± 2.91	1.5
16a	—	± 0	—	0	—	0	0
16b	9.1	66.7	20	17.9	24 ± 2.80	4.35 ± 3.47	2.9
17	16.7	67.1	20	26.4	24.6 ± 2.84	6.50 ± 5.37	4.4
18	2.0	16.7	—	—	—	—	—
19	16.7	34.1	20	8.5	31.5 ± 3.83	2.60 ± 1.96	0.9
20	20.0	50.0	21	16.8	22.2 ± 4.08	3.81 ± 2.82	1.9
21a	9.1	6.3	29	8.2	25.5 ± 4.15	2.14 ± 1.28	0.1
21b	16.7	25.0	20	17.2	25.3 ± 4.51	3.95 ± 2.86	1.0
22a	11.1	60.0	60	15.5	24.6 ± 2.86	3.90 ± 2.15	2.3
22b	< 1	± 0	—	0	—	0	0
23a	2.8	20.0	11	13.6	20.3 ± 1.79	2.72 ± 1.27	0.5
23b	16.7	12.5	22	12.2	20.2 ± 1.76	2.64 ± 1.76	0.3

(1) population	(2) %f	(3) % + b	(4) n	(5) %$\overline{N}_{b/f}$	(6) $\overline{N}_f$	(7) $\overline{N}_b$	(8) $\overline{N}_{b \times \%}$
24	25.0	—	20	10.5	28.2 ± 3.96	2.90 ± 1.86	—
25	16.7	9.1	9	6.8	22.1 ± 2.89	1.44 ± 0.73	0.1
26	25.0	50.0	20	21.3	22.5 ± 4.32	4.60 ± 2.96	2.3
27	9.1	50.0	20	10.1	25.1 ± 3.15	2.55 ± 1.93	1.3
28	33.3	± 4	12	5.5	29.5 ± 4.85	1.67 ± 1.16	0.1
29	16.7	9.1	11	6.6	31.2 ± 5.36	2.09 ± 1.38	0.2
30b	14.3	4.8	20	10.0	28.5 ± 2.35	2.85 ± 1.82	0.1
31	12.5	0	—	0	—	3.10 ± 1.71	0
32	—	—	>20	11.0	28.2 ± 3.57	3.10 ± 1.71	—
33	6.3	33.3	11	8.2	20.7 ± 1.42	2.64 ± 1.86	0.9
34	20.0	7.1	21	6.1	20.4 ± 4.01	1.19 ± 0.40	0.1
35	12.5	60.0	20	11.7	28.2 ± 3.22	3.35 ± 2.79	2.0
36	9.1	± 0	—	0	—	0	0
37	33.3	2.3	—	—	—	—	—
38	—	—	20	16.0	24.6 ± 3.49	3.90 ± 2.70	—
39	25.0	20.0	20	8.0	32.4 ± 3.94	2.55 ± 2.28	0.5
40	25.0	14.3	20	8.4	21.8 ± 3.29	1.85 ± 1.09	0.3
41	16.7	3.9	—	—	—	—	—
42	—	50.0	8	8.9	20.8 ± 3.15	1.75 ± 0.71	0.9
43	25.0	33.3	20	15.3	21.6 ± 3.24	3.25 ± 1.62	1.1
44	16.7	50.0	19	11.3	18.9 ± 2.56	2.21 ± 1.69	1.1
45	20.0	—	20	7.7	31.6 ± 4.29	2.45 ± 1.70	2.5
46	4.0	0	—	0	—	0	0

between these two vegetation types. Further, populations no. 21 and 36 were found in a *Fagus sylvatica* wood without undergrowth, no. 46 in a Salicion cinereae, and no. 2 in a Calluno-Genistion-pilosae-like vegetation. According to WESTHOFF & DEN HELD (1969) the soils belonging to these vegetation types are usually moderately rich in nutrients. The estimated coverage percentages of the species in the shrub and herb layer vary from 0–90% and are given in *table 3*.

3.4.3. Pollinating insects

In most of the populations visited in the flowering period insects were recorded on the *Maianthemum* plants. The following hoverfly taxa (Syrphidae) were identified (the symbol + indicates important in one or a few populations): *Baccha elongata* Fabr., *Chrysotoxum octomaculatum* Curtis (+), *Chr. verralli* Collin, *Dasysyrphus tricinctus* Fall. (+), *D. venustus* Mg. (+), *Didea intermedia* Loew, *Epistorphe nitidicollis* Mg., *Episyrphus balteatus* De G. (+), *E. cinctellus* Zett. (+), *Melanostoma scalare* Fabr. (+), *Myathropa florea* L., *Neoascia* spec., *Platycheirus* cf. *albimanus* Febr. and *P. scutatus* Mg. Some other pollinating insects belonged to the Apidae: *Bombus pratorum* L. and some specimens of unidentified *Bombus* species. Of the Anthomyidae and the Asilidae each one unidentified species was encountered. Particularly in the populations no. 5 and 6 pollination occurred very frequently. The Syrphidae usually visited a number of racemes

Table 3. Data concerning the environment of the 46 *Maianthemum* populations examined: acidity (pH) and coverage percentages of undergrowth (%un).

population no.	pH	%un	population no.	pH	%un
1	≤4	0	23a	5.3	15
2	—	0	23b	4.5	20
3a	≤4	30	24	—	25
3b	≤4	0	25	≤4	30
4	≤4	0	26	≤4	50
5	≤4	80	27	4.5	60
6a	≤4	40	28	4.5	20
6b	—	—	29	4.5	20
7a	4.5	0	30a	4.5	25
7b	≤4	20	30b	—	10
8a	4.5	10	31	5	—
8b	4.5	—	32	4.5	30
9	≤4	0	33	—	55
10	≤4	15	34	4.5	35
11	4.5	10	35	4.5	20
12	4.5	20	36	4.5	1
13	≤4	25	37	4.5	35
14	≤4	80	38	4.5	10
15	4.5	20	39	4.5	30
16a	—	—	40	4.5	35
16b	—	65	41	5	30
17	≤4	90	42	4.5	—
18	4.5	35	43	≤4	30
19	—	60	44	5	—
20	4.5	50	45	4.5	45
21a	4.5	1	46	4.5	—
21b	4.5	1			
22a	4.5	1			
22b	4.5	—			

in succession and many flowers within a raceme, where they consumed pollen. *Bombus* species, on the contrary, visited only one or two racemes very briefly. The Syrphidae thus appear to be the most important group for *Maianthemum* pollination in The Netherlands. SILVA et al. (1982) however, found for *M. canadense* mainly *Bombus* species as pollinators.

3.5. Experiments on fructification
3.5.1 Fructification after experimental pollination
Three pollination experiments were done, the first two in the field. In eleven populations extra cross-pollination was carried out once by hand on five plants. These additionally pollinated plants never showed a particularly high number of fruits and quite often even no production of fruits at all. In 1983 extra experimental pollination was carried out on 20 plants in population no. 6, of which fourteen were found again afterwards. The average number of fruits per plant was 2.43 ± 1.74 (range 0–5). Of a randomly selected control-group in this popu-

lation, which was open for natural pollination, these values were 2.12 ± 2.04 (range 0–8; n = 50). These differences did not appear to be significant (Kolmogorov-Smirnov two-sample test, D = 0.14). Of 69 plants kept under laboratory conditions 35 were regularly pollinated by stirring with a brush, which caused self-, neighbour- and cross-pollination by clouds of pollen, while 34 were left undisturbed. In the pollinated group 9.3% of the flowers produced a fruit, while this was 2.0% in the control-group, which seems to be a clear difference (not tested). So hand pollination had a positive influence on fructification here, which is in contrast with the findings in the field (see above).

3.5.2. Fructification under experimental air humidity conditions
The numbers of plants forming fruits under air humidity conditions of 10–50%, 50–70% and c. 96% were 2.0%, 42.6% and 43.1%, respectively. On an average respectively $0.02 \pm 0.14, 0.75 \pm 1.15$ and 1.00 ± 1.39 berries per fruiting plant were produced.

3.6. Experiments on germination
The stratification of berries with at all 811 seeds was terminated about the middle of January 1983. At the end of February a few seeds started germinating and at April 14th 12.6% of all seeds had germinated. Of the 176 seeds in 160 berries sown in October 1984 3% had germinated at the end of June 1985. These results indicate that *Maianthemum bifolium* has a slow and irregular germination, which was also noted by KAWANO et al. (1968a).

4. EXAMINATION OF CORRELATIONS BETWEEN VARIOUS RESULTS

4.1. Flower–fruit correlation
The values of mean number of flowers per fruiting plant (N_f) and of mean number of fruits per fruiting plant (N_b) of the 46 populations were tested for correlation with the Spearman rank correlation test. The result (R = 8264.5, n = 38, p > 0.05) was not significant. Moreover, the correlations between the means of N_f in nine randomly selected populations and four fruit-classes were examined with the Kruskal-Wallis test. The four classes were formed by plants with one, two, three, and four or more fruits respectively. The result (H = 0.092, p > 0.05) was not significant, which means that no fruit-class had generally higher or lower values of N_f than the others. So it can be stated that there is no correlation between the number of fruits and the number of flowers in a raceme.

4.2. Undergrowth–fruit yield association
Correlations were examined between percentage undergrowth (%un) and four aspects of fruit yield, viz. mean number of fruits per fruiting plant (N_b), mean number of fruits per flowering plant ($N_{b \times \%}$), mean percentage of flowers developing into fruits (%$N_{b/f}$) and the percentage of flowering plants forming one or more fruits (% + b). Both sides of the estimated optima in scattergrams,

at $\%$un $= 35$, were tested. The following results were found, the first three with the Spearman rank correlation test and the last with the Olstead and Tukey's corner test for association.

N_b $- \%$un $\geqslant 35 : R = 50^{***}$ (n $= 13$), significant

$N_{b \times \%} - \%$un $\geqslant 35 : R = 50^{**}$ (n $= 12$), significant

$\%N_{b/f} - \%$un $\geqslant 35 : R = 85^{**}$ (n $= 13$), significant

$\% + b - \%$un $\geqslant 35 : S = 17^{**}$ (n $= 14$), significant

Tests at $\%$un $< 35\%$ could not be carried out because to many values had the same rank. Scattergams did not seem to indicate (simple) correlations.

4.3. Soil acidity–fruit yield correlation

For two pH classes, viz. pH $\leqslant 4$ and pH ≈ 4.5 the means of N_b, $N_{b \times \%}$, and $\%N_{b/f}$ were calculated as follows (for symbols see 4.2).

	$\overline{N_b}$	$\overline{N_{b \times \%}}$	$\overline{\%N_{b/f}}$
pH $\leqslant 4$	3.9 ± 1.52 (15)	2.2 ± 1.51 (11)	17.1 ± 5.48 (11)
pH ≈ 4.5	2.8 ± 0.99 (11)	1.1 ± 0.94 (18)	10.8 ± 4.01 (20)

The differences between the two pH-classes were tested with the Mann-Whitney U-test, with as results those given below.

N_b : ts $= 2.40^*$, significant

$N_{b \times \%}$: ts $= 2.05^*$, significant

$\%N_{b/f}$: ts $= 2.83^*$, significant

Thus populations on places with pH $\leqslant 4$ produced generally more fruits than those on places with pH ≈ 4.5.

5. DISCUSSION AND CONCLUSIONS

A low fruit yield as we found in *Maianthemum bifolium* was established previously in *M. canadense* (SILVA et al. 1982) as well as in *M. dilatatum* and *M. bifolium* (KAWANO et al. 1968a), always combined with a large vegetative reproduction. This strategy is fairly common in herbaceous wood-plants, e.g. *Oxalis acetosella* (PACKHAM 1978) and *Anemone nemorosa* (ERNST 1983). The following discussion will be focussed at the principles that might explain the differences in fruit production between various *Maianthemum* populations.

SILVA et al. (1982) presume a negative correlation between the percentage of flowering plants in a population and the mean number of fruits produced by these plants. In this study, on the contrary, neither a positive nor a negative correlation was established between numbers of flowers and fruits in the populations (see 4.1).

KAWANO et al. (1968a) considered *M. dilatatum* and *M. bifolium* to be outbreeding species, while the same was found in *M. canadense* by SILVA (1978). From our observations it seems likely that cross-pollination is not obligatory and that self-pollination results in fruit setting.

SILVA (1978) and SILVA et al. (1982) supposed that fluctuations in fruit produc-
tion were due to fluctuations in abundance of pollinating insects. According
to KAWANO et al. (1968a) the generally low fruit yield in southern and central
Japan was due to the absence of insects consequent on a high rainfall. On the
other hand, we found that different numbers of pollinating insects could not
have caused the differences in fruit yield. This conclusion is based on the follow-
ing arguments. In several populations which were equally well visited by insects,
e.g. no. 5 and 6, distinct differences in fruit production were established. When
insect pollination plays the chief role in fruit production, as a consequence, a
correlation between number of flowers and that of fruits would be likely. How-
ever, such a correlation did not prove to exist. For example, between different
parts of populations, apparently showing a comparable number of pollinating
insects, differences were found in fruit production. Furthermore population no.
6 had a distinctly higher fruit yield in 1983 than in 1982, although in both years
pollinating insects were abundant here. Finally, the Japanese populations show-
ed a similarly low fruit production as the Dutch ones, although in the first no
pollinating insects were recorded. It seems likely that insects effect cross-pollina-
tion by transport of pollen as well as self-pollination by stirring flowers.

In the present study it was found that air humidity during and also shortly
before and after the flowering period is much more important for actual fruit-
setting. The following arguments favour our explanation. In laboratory experi-
ments more fruits were produced under high air humidity conditions than under
low. In most populations a varying number of partly parched racemes, in bud
and/or flower stage, was found, which probably was due to dry air conditions.
Low and dense undergrowth, which could prevent withering by maintaining
a high air humidity, was found to be correlated with a high fruit yield. In 1982
– with an unusually dry spring – the mean fruit production per fruiting plant
in population no. 6 was 1.8, whilst in 1983 – after a damp spring – this mean
was 4.2.

Also SILVA et al. (1982) found a consistent fluctuation in fruit yield for six
populations of the same region over three years, which appear to be due to
corresponding micro-climatological conditions. KAWANO et al. (1968a) found
generally lower values of fruit yield for southern and central than for northern
Japan, which may be explained too by differences in air humidity. Selfincompati-
bility of *Maianthemum* clones may influence to some degree fructification, al-
though SILVA et al. (1982) made plausible that this is not the case. By working
randomly we have tried to avoid, as much as possible, the complications caused
by the presence of clones.

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