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GROWTH CONTROL OF TRIBONEMA MINUS (WILLE) HAZEN AND SPIROGYRA SINGULARIS NORDSTEDT BY LIGHT AND TEMPERATURE

P. J. R. DE VRIES and H. HILLEBRAND

Biologisch laboratorium, Vrije Universiteit, Postbus 7161, 1007 MC Amsterdam

SUMMARY

Optimum growth in uni-algal cultures of *Tribonema minus* (Wille) Hazen, a dominant alga in blanketing algal mats in the early spring, was obtained at temperatures between 15–25 °C and light intensities above 18 μ Einstein $m^{-2} s^{-1}$. Uni-algal cultures of *Spirogyra singularis* Nordstedt, dominant in algal mats during summer, grew well between 20–25 °C and the highest light intensities tested (62 μ Einstein $m^{-2} s^{-1}$). In mixed cultures *T. minus* outgrows *S. singularis* below 13 μ Einstein $m^{-2} s^{-1}$ and 15 °C. At higher light intensities and temperatures levels *S. singularis* dominates, which agrees with field observations. The growth reduction of *T. minus* at these higher levels is discussed.

1. INTRODUCTION

Shallow eutrophic fresh waters are often characterized by the presence of blanketing algal mats during spring and summer (DE LANGE & VAN ZON 1973, HILLEBRAND 1977, MARVAN *et al.* 1978a, 1978b). These mats consist of various filamentous algae, in majority representatives of the genera *Cladophora, Oedogonium, Spirogyra, Tribonema* and *Ulothrix*. The abundance of the individual species shows a specific periodicity (HILLEBRAND 1983). Generally, *Tribonema* species are dominant in early April, while most *Spirogyra* species occur abundantly in May and June. This seasonal pattern suggests that light and temperature are important factors regulating algal periodicity (HILLEBRAND 1985). The present study investigates the growth of *T. minus* and *S. singularis*, both being dominant algae of early spring and summer algal mats, under various light intensities and temperatures.

2. MATERIALS AND METHODS

Uni-algal cultures of *Tribonema minus* (Wille) Hazen and *Spirogyra singularis* Nordstedt were used as test organisms. The algae were grown in 50-ml culture jars (4 cm diameter), each containing 19 ml Wood's Hole medium (STEIN 1973, slightly modified according to FRANCKE & TEN CATE 1980). The culture jars were placed in a modified version of the Edwards & Van Baalen's light-temperature gradient plate (EDWARDS & VAN BAALEN 1970).

Each expeiment involved the culture of the test species, single or as a mixture, in series of thirty-six culture jars at combinations of the following temperatures and light intensities; 4.4, 9.4, 20.0, 25.0, and 30.0 °C and 2, 3, 6–7, 13–18, 32–36 and 60–62 µ Einstein $m^{-2} s^{-1}$ (LI-COR photometer, LI-185A). The experiments were conducted at 12:12, 14:10 and 16:8 light-dark regimes.

Tufts of algae were fragmented with a razor blade into filaments of 5–9 cells. 1 ml of this suspension was used as inoculum in the single species test and 0.5 ml in the mixed species tests, respectively.

Biomass was measured in the exponential growth phase, after 12–13 days of incubation. The algae were fragmented ultrasonically in the culture jars and the optical density of the obtained suspension of filaments was measured at 798nm (De Vries & Kamphof 1984). Cell counts were performed on the mixed cultures using the homogenous suspension. The cells of the individual species remained identifiable. The growth of the species in the uni-algal cultures was expressed as the ratio in optical density 798 nm measured at the end and the beginning of the experiments or as the ratio of the number of cells in the mixed cultures.

3. RESULTS

The growth obtained in the uni-algal culture experiments conducted at the various light-dark regimes is presented in *fig. 1* and *2*. The overall growth responses between the different light-dark regimes did not notably differ. The variation in ratios between the different light-dark regimes was within the same range as that between series conducted at one regime (not shown). *T. minus* showed

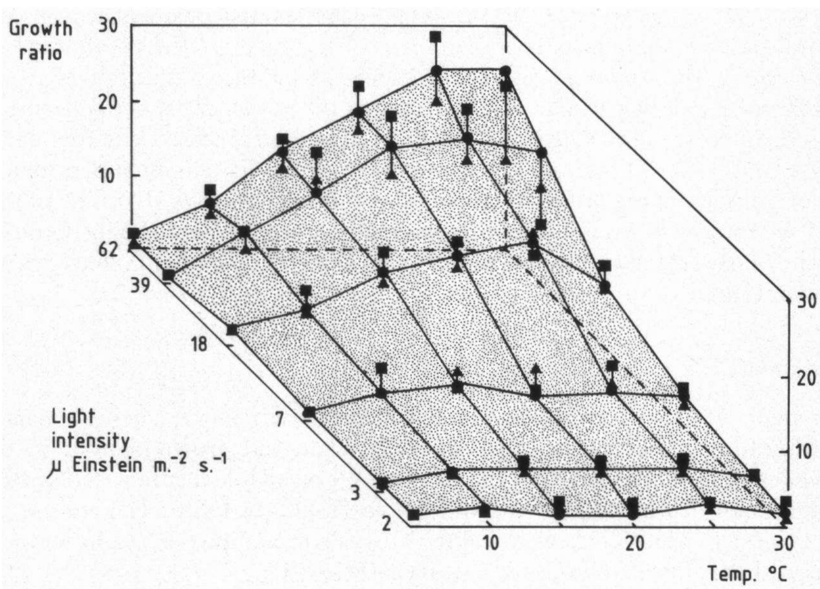

Fig. 1. Growth of *Spigogyra* at various temperatures and light intensities, (O–O) 12:12 hr light-dark regime, (△–△) 14:10 hr light-dark regime, (□–□) 16:8 hr light-dark regime.

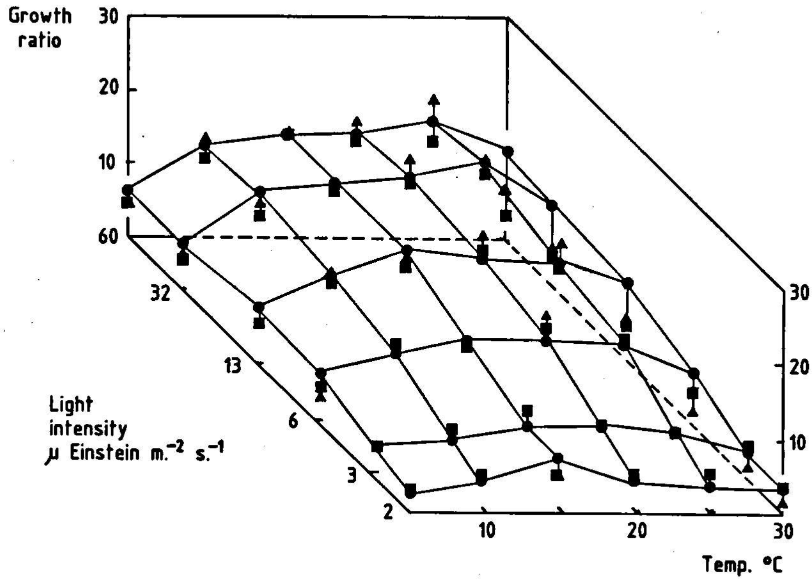

Fig. 2. Growth of *Tribonema* at various temperatures and light intensities, (○–○) 12:12 hr light-dark regime (△–△) 14:10 hr light-dark regime, (□–□) 16:8 hr light-dark regime.

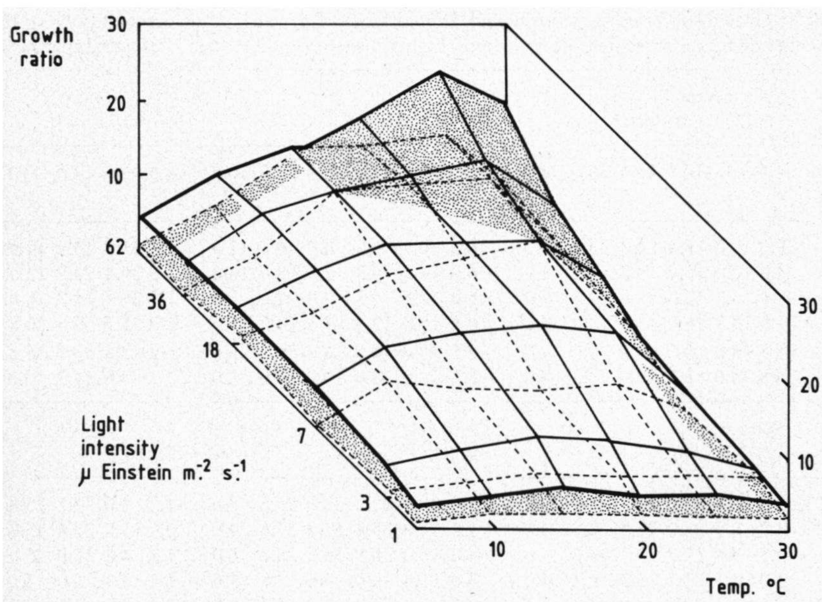

Fig. 3. Predicted growth, based on the results in unialgal cultures of *Spirogyra* (dotted) and *Tribonema* (blank).

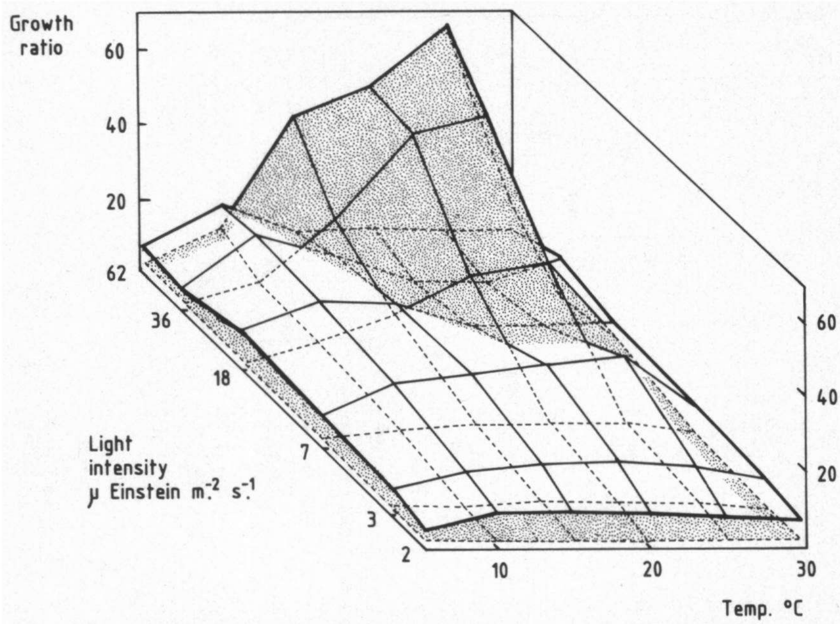

Fig. 4. Actual growth obtained in mixed cultures of *Spirogyra* (dotted) and *Tribonema* (blank).

Table 1. Growth of *Tribonema minus* and *Spirogyra singularis* at various combinations of temperature and light intensity in three light-dark regimes. Light intensities in $\mu E\ m^{-2}\ s^{-1}$, temperatures in °C.

	Tribonema 12:12 h light/dark regime						14:10 h						16:8 h					
temp. light	4.4	9.4	14.5	20.0	25.0	30.0	4.4	9.4	14.5	20.0	25.0	30.0	4.4	9.4	14.5	20.0	25.0	30.0
62	9.0	16.8	8.4	4.8	5.2	14.2	6.3	6.5	6.0	8.0	10.5	12.5	7.3	31.8	18.2	18.0	16.3	17.2
36	8.0	12.0	11.4	8.2	5.2	8.0	8.0	17.5	5.3	7.3.3	8.0	10.0	5.0	29.8	20.7	12.6	11.2	23.8
18	8.0	16.8	12.0	15.0	9.6	8.0	15.0	12.5	5.3	8.0	9.0	7.5	7.2	26.8	21.7	18.6	16.8	11.6
7	7.0	12.8	16.0	15.4	18.0	9.0	10.5	15.8	12.5	19.3	24.0	11.3	7.0	25.7	30.3	26.8	27.6	13.8
3	5.6	8.0	9.6	9.6	8.0	7.2	5.0	10.0	10.0	14.0	10.5	9.0	6.2	13.8	18.7	18.6	18.5	13.3
2	4.8	5.6	6.4	6.4	4.8	4.0	3.8	8.0	8.0	10.0	9.0	8.0	–	8.6	11.7	10.6	9.0	8.2
	Spirogyra 12:12 h						14:10 h						16:8 h					
62	3.2	9.6	34.0	46.8	59.8	29.8	5.0	20.8	43.2	57.6	75.6	8.0	1.2	5.0	37.2	33.8	61.8	44.1
36	4.8	6.4	16.0	47.9	59.8	4.8	1.6	14.0	37.8	52.2	57.6	4.0	0.9	5.0	23.6	45.8	63.4	13.5
18	3.2	8.8	11.2	20.7	31.6	9.6	4.0	10.0	20.8	25.6	28.8	6.0	1.2	4.4	15.0	25.0	30.9	15.3
7	4.0	5.3	2.7	5.3	6.4	4.0	3.6	5.4	10.0	6.6	4.8	1.0	1.2	4.1	5.0	4.2	9.4	2.6
3	2.1	2.7	1.6	4.8	3.4	2.1	4.0	2.0	2.0	2.8	3.6	0.8	2.4	2.4	3.6	3.2	3.0	2.1
2	1.1	2.1	0.8	0.8	1.1	1.6	3.0	1.6	1.6	2.0	0.8	1.6	–	1.5	1.8	1.8	1.5	1.5

maximum growth at light intensities beyond 13 μ Einstein m^{-2} s^{-1} and at temperatures between 15–25 °C. The growth slightly decreased at lower temperatures and light intensities. However *T. minus* could still grow at 4.4 °C and at light intensities beneath 6 μ Einstein m^{-2} s^{-1}. All tested light intensities were subtoptimal for *S. singularis (fig. 1)*, the optimum temperature for growth being between 20–30 °C. At the lowest temperatures and light intensities tested, growth for this alga could hardly be recorded.

The results obtained in the uni-algal cultures can be used to predict the growth of both algae in mixed cultures. As stated previously, the growth responses at the different light-dark regimes only slightly differ. Therefore data obtained under different light-dark regimes were averaged. Straight line graphical interpolation of the results obtained in the uni-algal experiments was applied to estimate the growth ratio in mixed cultures. The graphical model is presented in *fig. 3*. It is expected that *S. singularis* will outgrow *T. minus* at higher temperatures and light intensities, while in the lower regions dominance of *T. minus* over *S. singularis* is expected.

The actual growth of the mixed cultures of the two species at the various light-dark regimes is presented in *table 1*. The average response to the various light-dark regimes is presented in *fig. 4*. By comparing the estimated growth (observed in the unialgal cultures) with the actual growth (in mixed cultures) it becomes obvious that below 15 °C and 18 μ Einstein m^{-2} s^{-1} *T. minus* outgrows *S. singularis* and in the higher regions *S. singularis* becomes dominant. However, *T. minus* is relatively reduced in its growth in the region were *S. singularis* is dominant, but *S. singularis* seems to be rather unaffected in its growth where *T. minus* dominates.

4. DISCUSSION

From the present study it may be concluded that temperature and light are important factors determining the natural periodicity of *T. minus* and *S. singularis*. In the mixed cultures *T. minus* dominates over *S. singularis* at water temperatures below 15 °C and light intensities below 18 μ Einstein m^{-2} s^{-1}. These experimental results agree with field observations and reports from WHITFORD & SCHUMACHER (1963). They stated that for many species of freshwater algae 15 °C seems to be a critical temperature. Most winter and early spring species disappear or become reduced in abundance as the temperature exceeds 15 °C. When the water warms above this temperature species of *Mougeotia* and *Spirogyra* replace other filamentous algae such as *Tribonema*. AUER *et al.* (1983) reported that *Cladophora* displaced *Ulothrix* from deeper waters when temperatures rise above 10–15 °C.

The present results indicate that *T. minus* grows well at low light intensities, which favours its growth at winter and early spring conditions. The low light intensities that reach the bottom of the waterbody and low temperatures are sufficient to induce a massive growth of *T. minus*. Therefore this species can occur early in the year and floating mats are present in early spring.

T. minus shows growth reduction when *S. singularis* is dominant in mixed cultures, whereas *S. singularis* seems unaffected by *T. minus* dominance. Competition for nutrients in the batch cultures may be responsible for this growth reduction. The uptake of nutrients by the fast growing *S. singularis* may exceed the uptake by *T. minus* at higher temperatures and light intensities. *S. singularis* therefore can grow on the luxury uptaken nutrients, while *T. minus* is restricted in its growth.

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