THE ROLE OF NUTRIENT UTILISATION AND PHOTOSYNTHETIC CAPACITY IN MICRO-ALGAL BLOOM FORMATION AND THE PRODUCTION OF CYANOTOXINS

APPENDIX A

by

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CHAPTER 2
LITERATURE REVIEW ON THE HARMFUL ALGAL BLOOMS

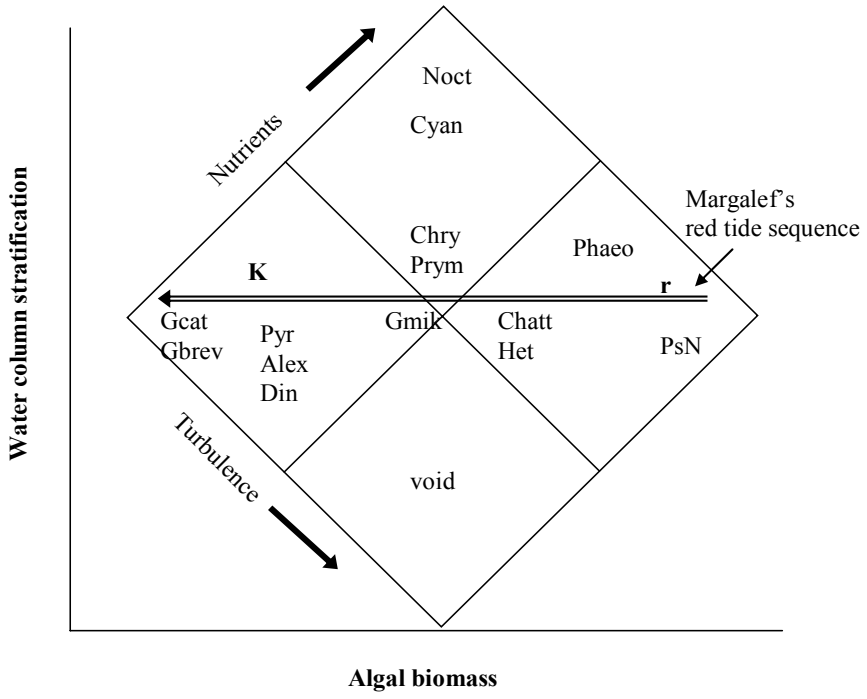


Figure 2.1. An adaptation of "Margalef's Phytoplankton Mandala", modified from Hallegraeff (1998), showing the preference of certain algal genera or species to different nutrient and turbulence conditions (square), which is superimposed on the plane defined by the coordinates production potential (algal biomass) and water column stratification. Margalef's original "red tide sequence" is marked with the horizontal arrow. K represents species that display K-strategic features, and r represents r-strategic species. Alex = Alexandrium, Chatt = Chattonella, Chrys = Chrysocromulina, Cyan = Cyanobacteria, Din = Dinophysis, Gbrev = Gymnodinium breve, Gcat = Gymnodinium catenatum, Gmik = Gymnodinium mikimotoi, Het = Heterosigma, Phaeo = Phaeocystis, Prym = Prymnesium, Noct = Noctiluca, PsN = Pseudo-nitzschia, Pyr = Pyrodinium.

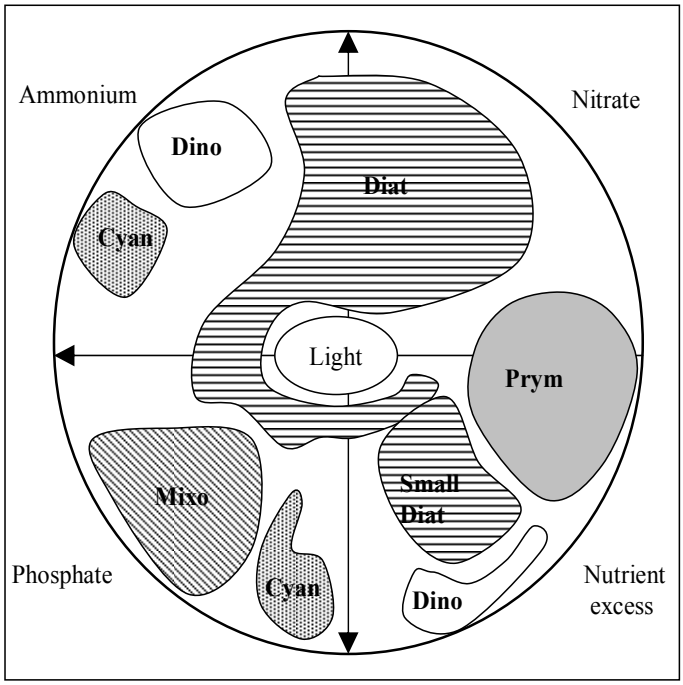


Figure 2.2. Ecological clusters as suggested by Riegman (1998), describing species clusters of dinoflagellates (Dino), diatoms (Diat), haptophyceae (Prym), cyanobacteria (Cyan) and mixotrophic algae (Mixo) based on their preference to differing light and nutrient conditions. The center of the circle indicates light limiting conditions, the border of the circle light saturating levels and nutrient limitation or nutrient excess.

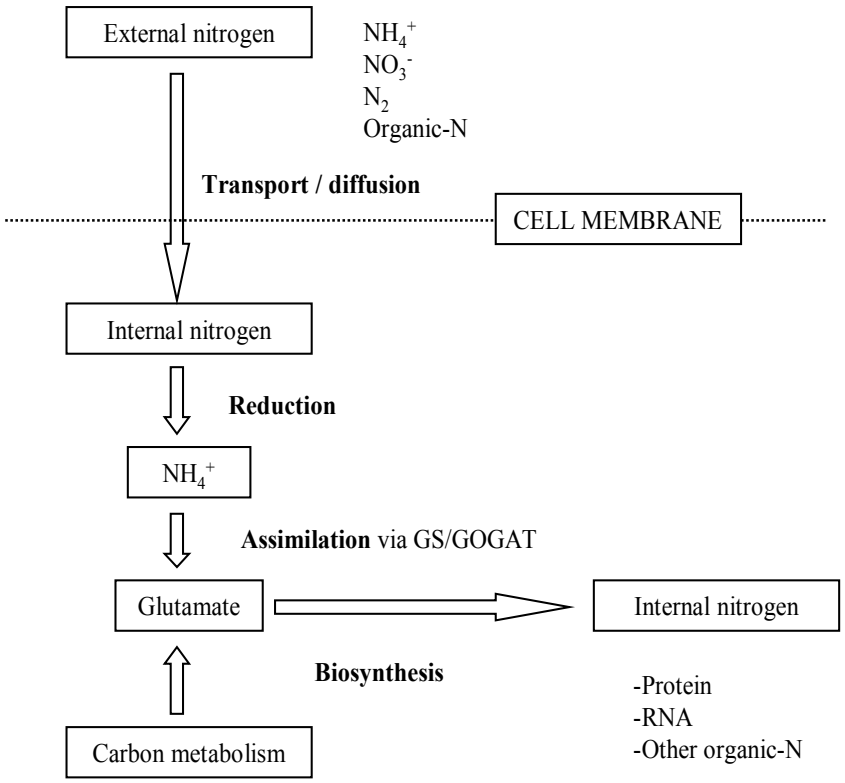


Figure 2.3. Major steps in phototrophic nitrogen uptake, assimilation and biosynthesis (according to Vincent 1992).

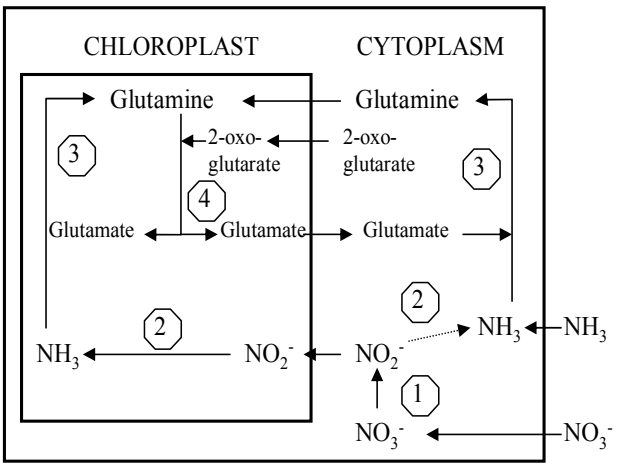


Figure 2.4. Compartmentation of the flow of compounds during the assimilation of nitrate and ammonium in *Chlamydomonas reinhardtii*, according to Fischer and Klein (1988).

1. Nitrate reductase, 2. Plastidic and cytoplasmic nitrite reductase, 3. Plastidic and cytoplasmic glutamine synthetase (GS), 4. GOGAT.

CHAPTER 3

GROWTH, PHOSPHATASE ACTIVITY AND PHOTOSYNTHETIC VITALITY OF TWO CYANOBACTERIA UNDER DIFFERENT NUTRIENT CONDITIONS

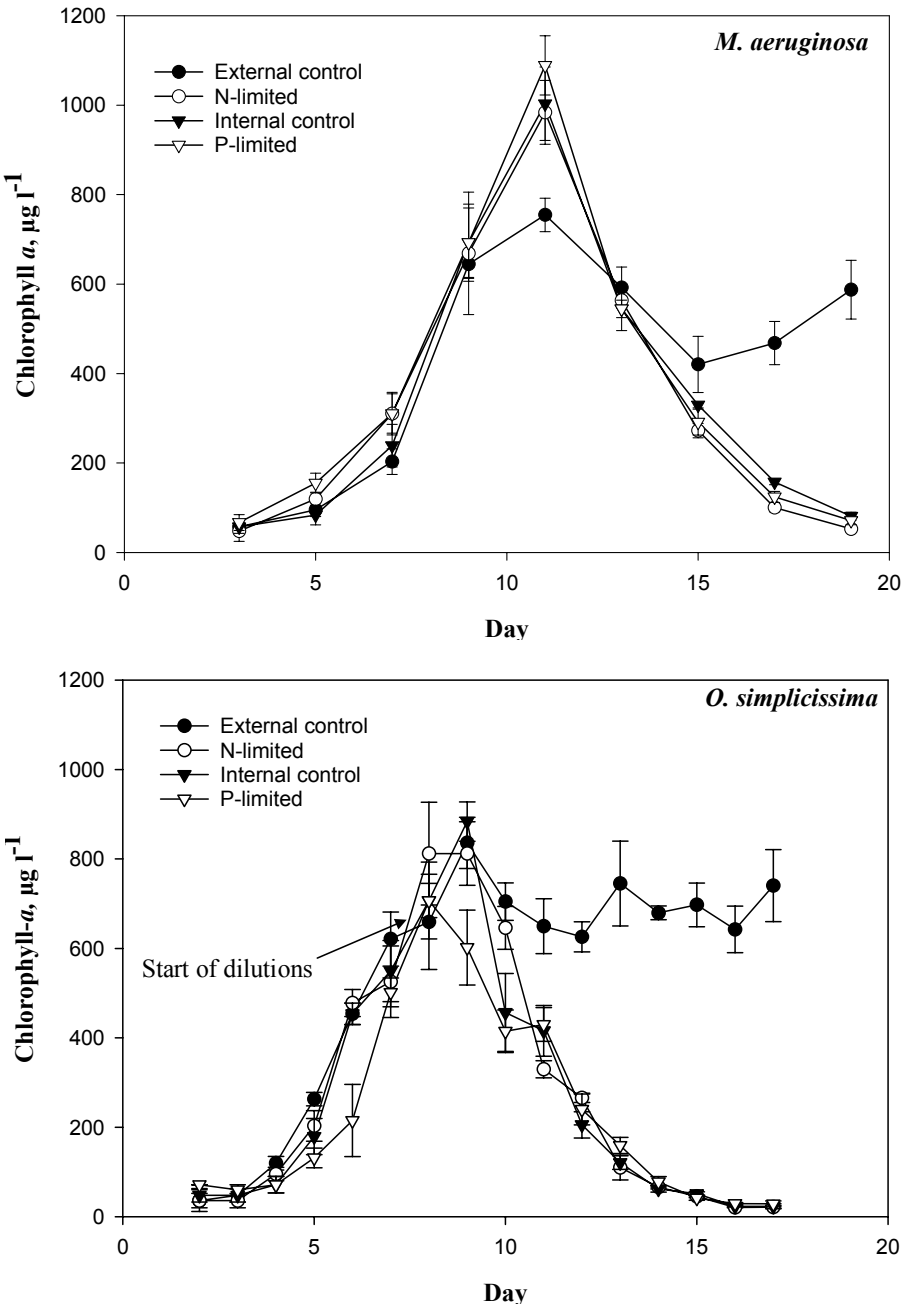


Figure 3.1. Growth of *Microcystis aeruginosa* (A) and *Oscillatoria simplicissima* (B) throughout the experiment (means and standard error of chlorophyll-*a* concentrations). The dilutions were started on day 11 and 8 respectively. The experiment was finished on day 18 and 17 respectively.

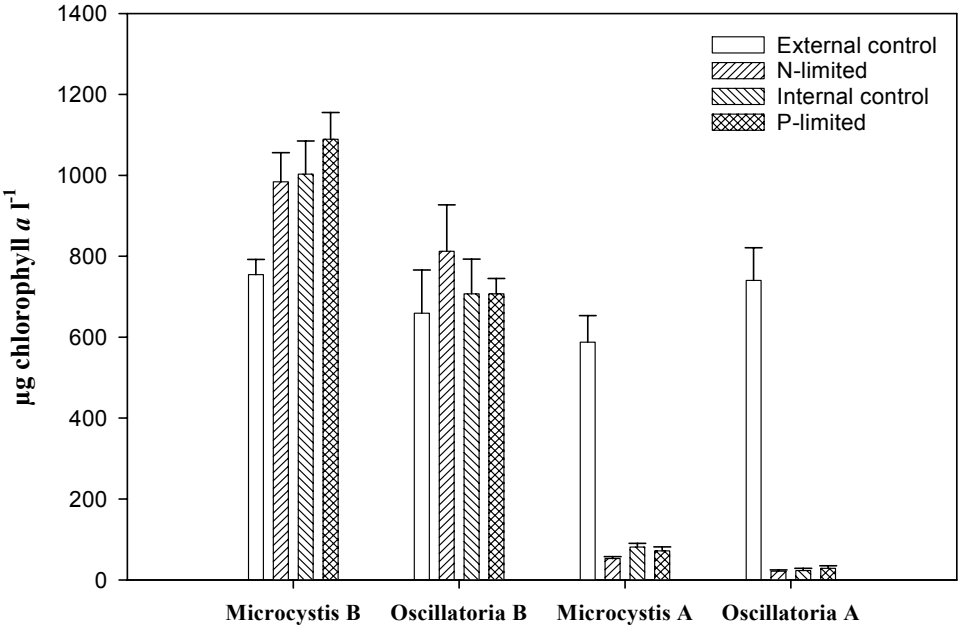


Figure 3.2. Chlorophyll-*a* concentration (mean and standard error for six samples) for *Microcystis aeruginosa* and *Oscillatoria simplicissima* initially (B = before treatment) and after (A = after treatment) being exposed to varying N:P ratios (External control = EM medium).

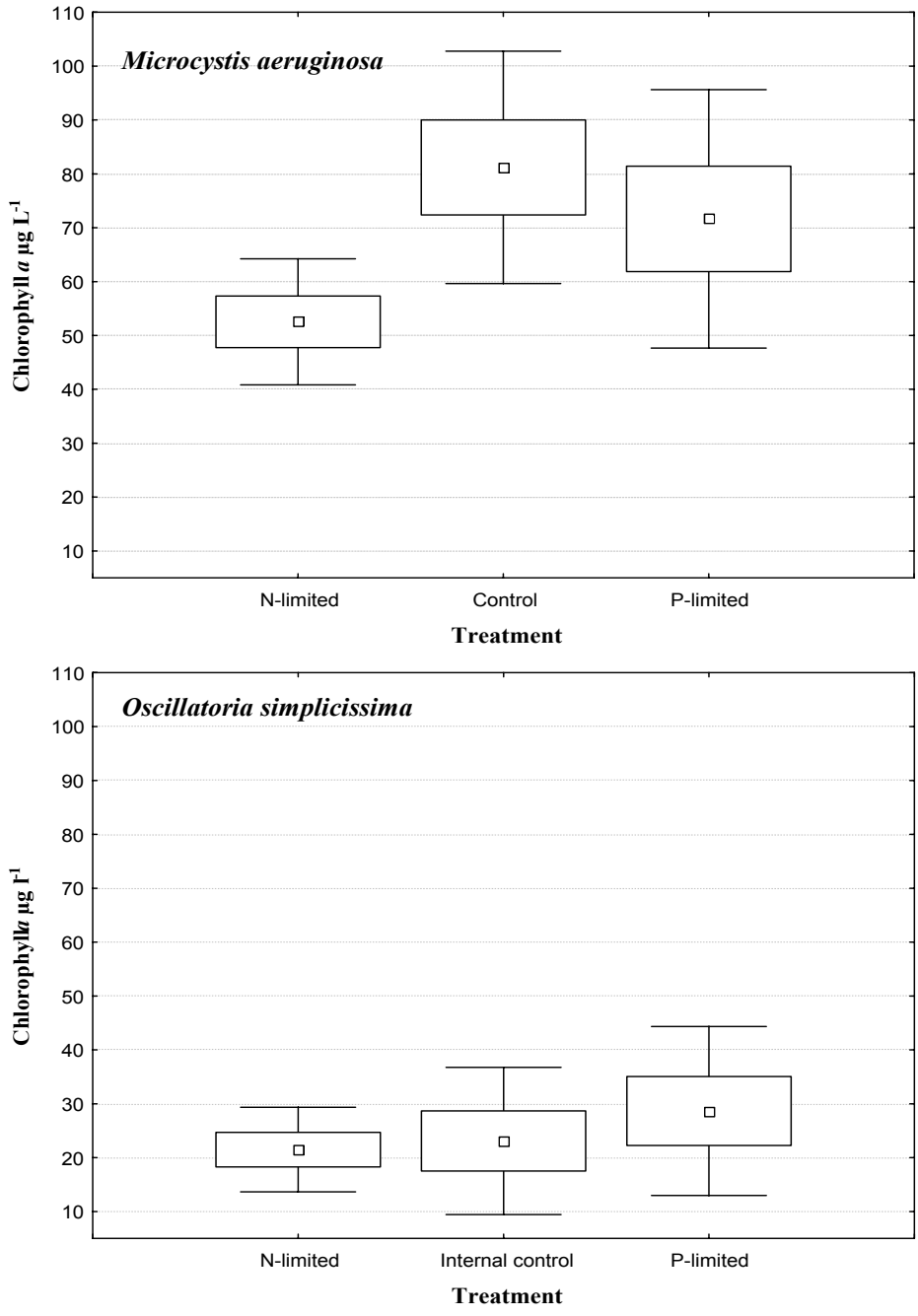


Figure 3.3. Chlorophyll-*a* concentrations of *Microcystis aeruginosa* (A) and *Oscillatoria simplicissima* (B) at the end of the experiment in the three experimental treatments. Averages marked by rectangle, boxes include standard error and whiskers mark standard deviation, n = 6 in each treatment.

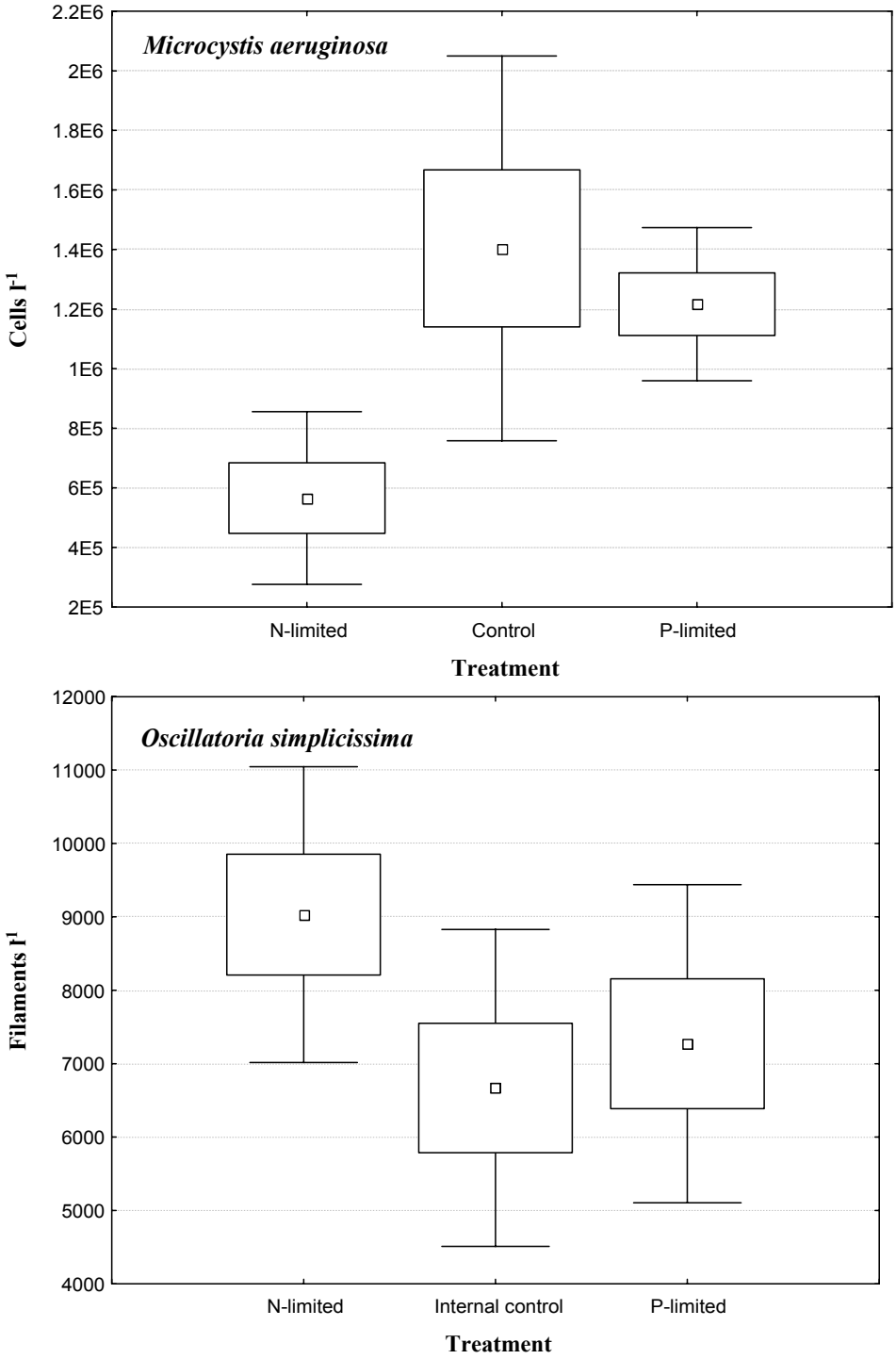
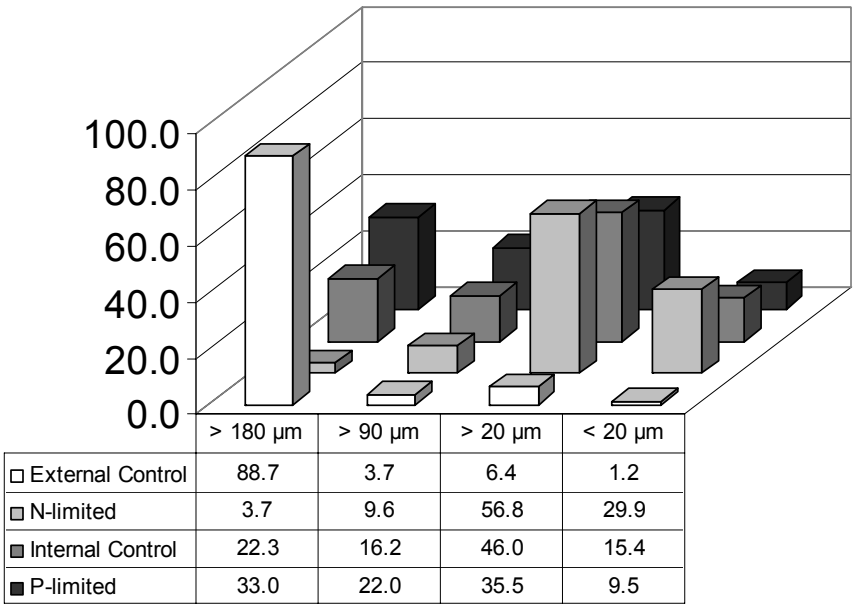


Figure 3.4. Number of cells / filaments of *Microcystis aeruginosa* (A) and *Oscillatoria simplicissima* (B) at the end of the experiment in the three experimental treatments. Averages marked by rectangle, boxes include standard error and whiskers mark standard deviation, n = 6 in each treatment.



	> 180 µm	> 90 µm	> 20 µm	< 20 µm
External Control	88.7	3.7	6.4	1.2
N-limited	3.7	9.6	56.8	29.9
Internal Control	22.3	16.2	46.0	15.4
P-limited	33.0	22.0	35.5	9.5

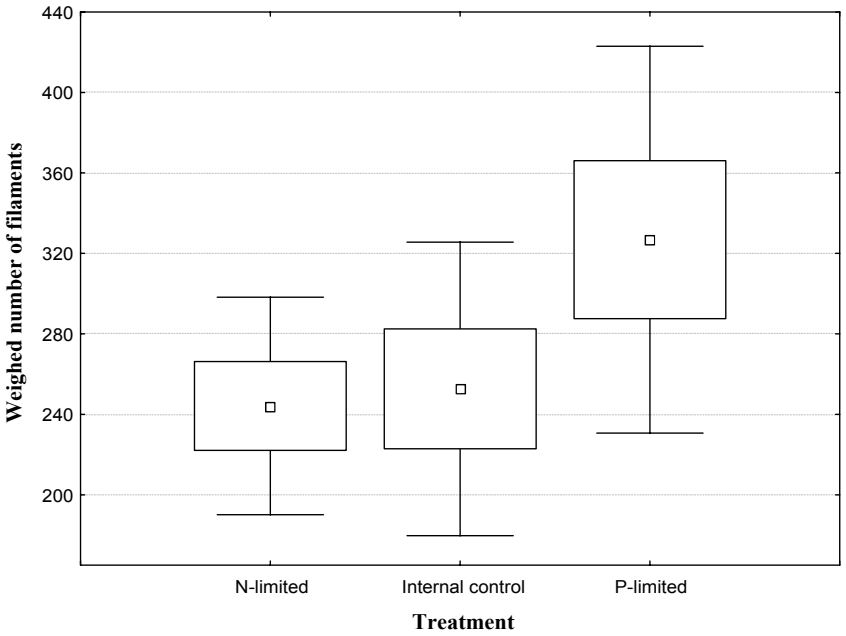


Figure 3.5. Variation in the size classes of *Oscillatoria simplicissima* grown under varying nutrient regimes. The uppermost figure presents the percentage distribution of filaments in four size classes in all treatments including the external control (EM medium). The box and whisker plot below presents the mean (middle point), standard error (box value) and standard deviation (whisker value) of weighed number of filaments to indicate biomass in the samples.

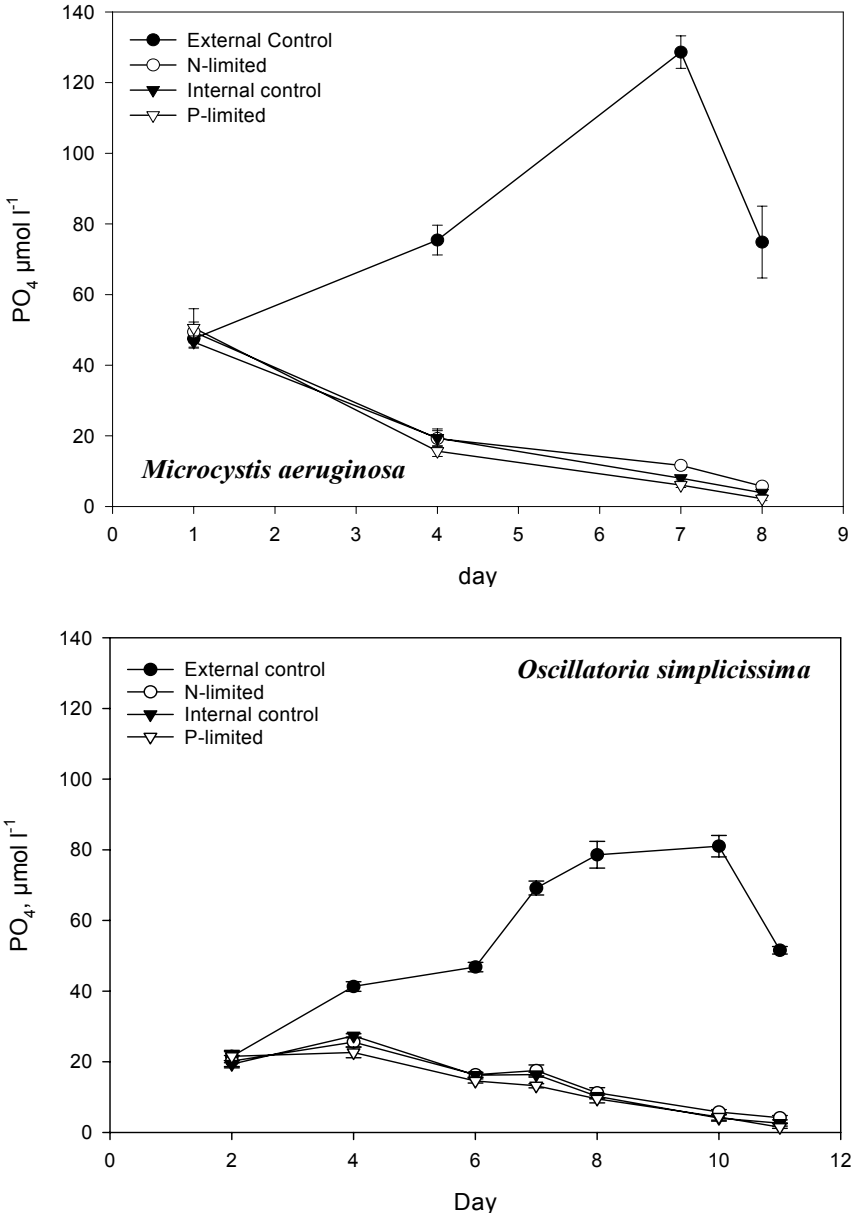


Figure 3.6. Gradual change in the phosphate concentrations (mean and standard error for six samples) in the culture medium of *Microcystis aeruginosa* and *Oscillatoria simplicissima* throughout the experiment (External control = EM medium). Samples are taken every second - third day after the start of dilutions.

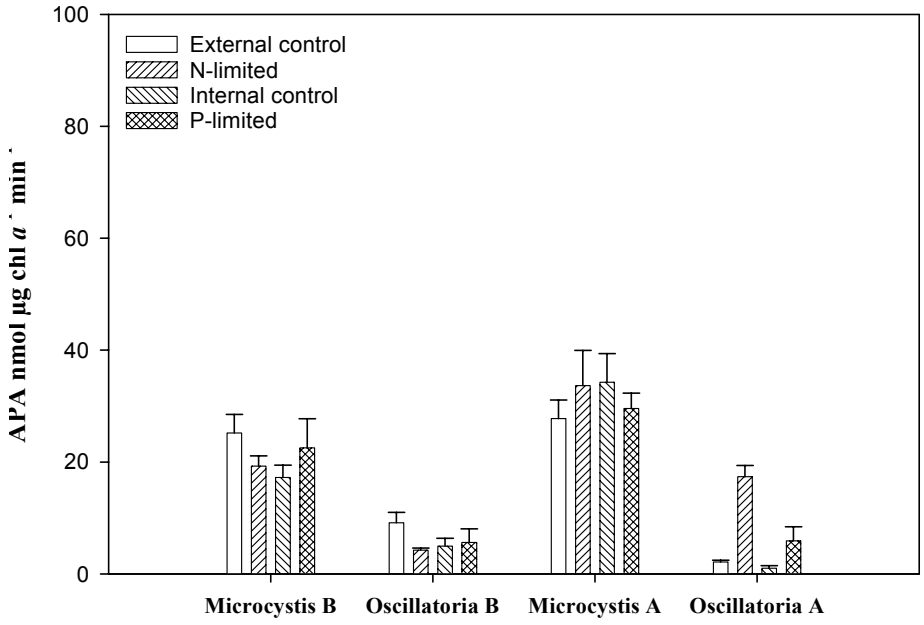
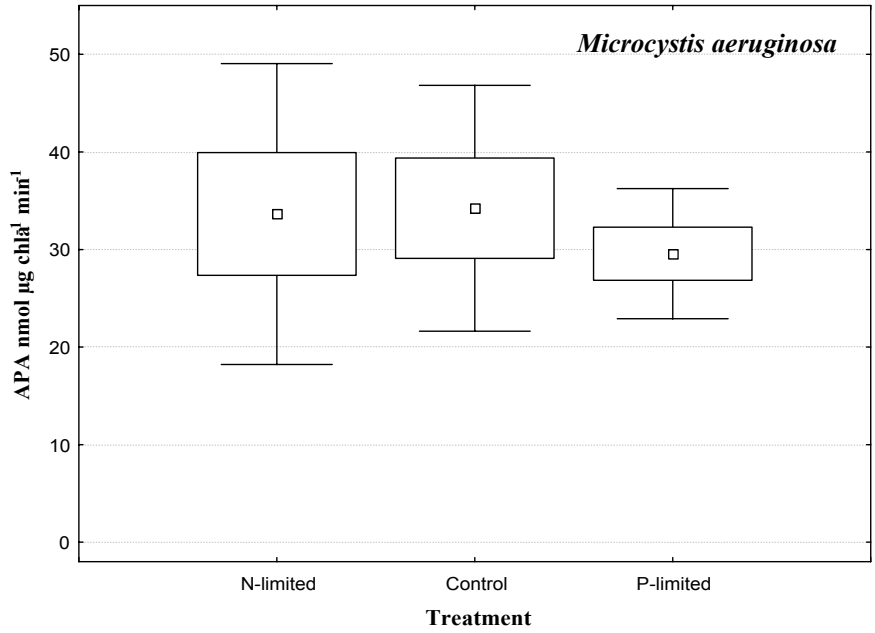


Figure 3.7. Alkaline phosphatase activity (mean and standard error for six samples) for *Microcystis aeruginosa* and *Oscillatoria simplicissima* initially (B = before treatment) and after (A = after treatment) being exposed to varying N:P ratios (External control = EM medium).



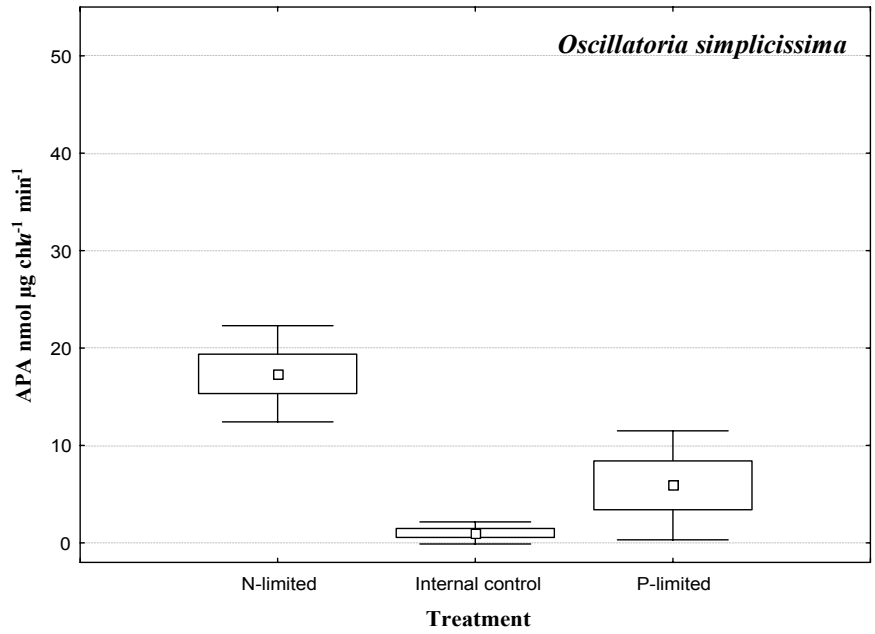


Figure 3.8. Specific alkaline phosphatase activity of *Microcystis aeruginosa* and *Oscillatoria simplicissima* at the end of the experiment in the three experimental treatments. Averages marked by rectangle, boxes include standard error and whiskers mark standard deviation, n = 6 in each treatment.

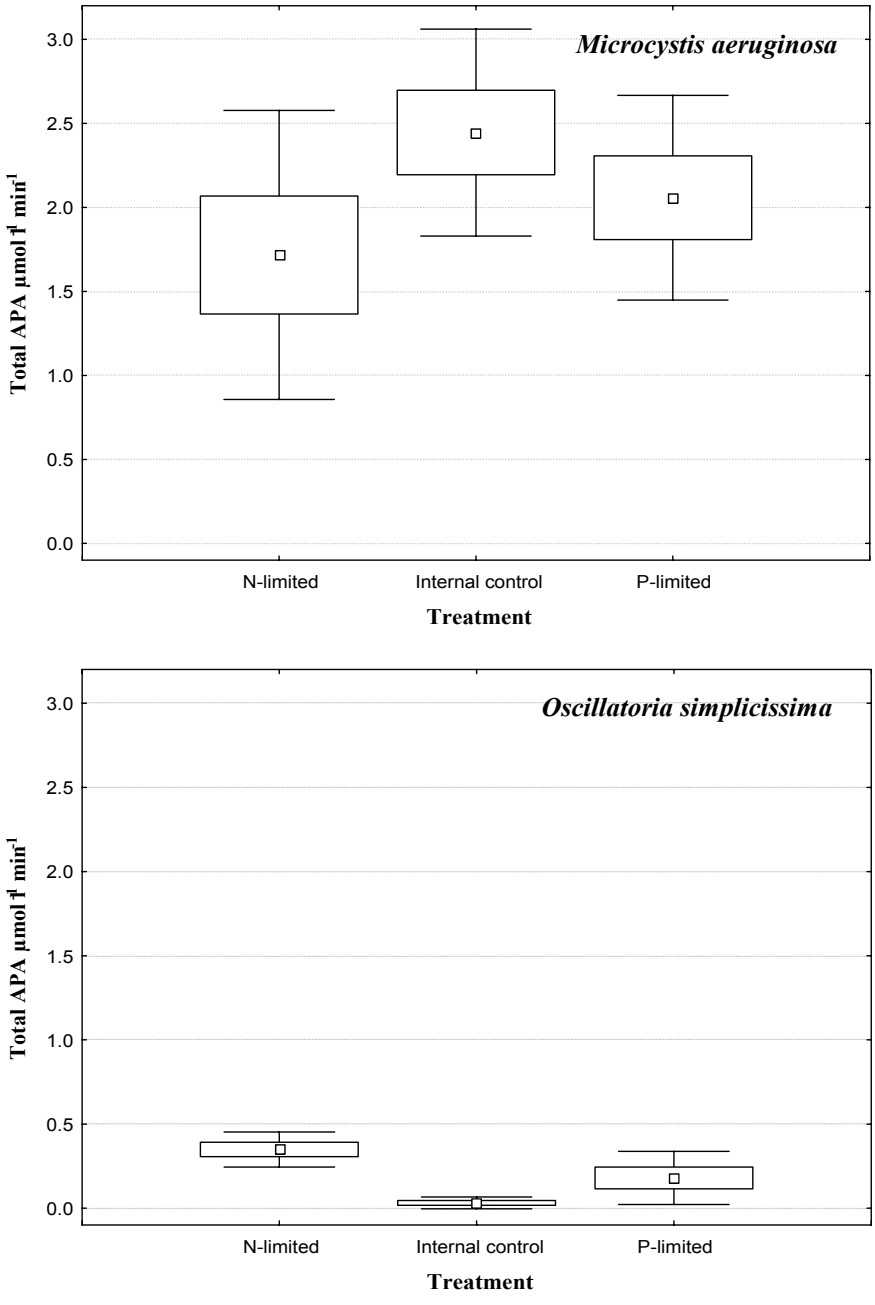


Figure 3.9. Total alkaline phosphatase activity of *Microcystis aeruginosa* and *Oscillatoria simplicissima* at the end of the experiment in the three experimental treatments. Averages marked by rectangle, boxes include standard error and whiskers mark standard deviation, n = 6 in each treatment.

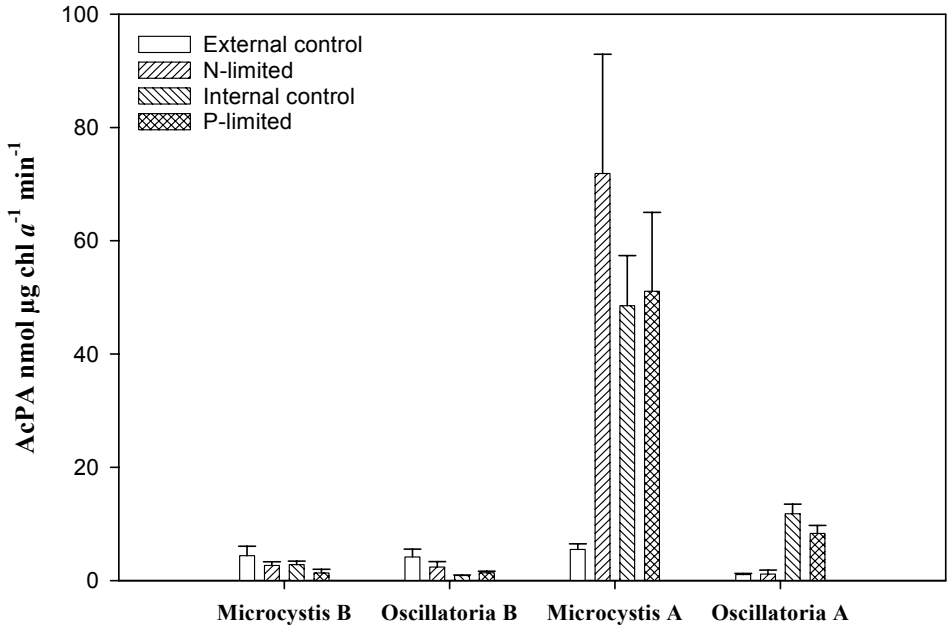


Figure 3.10. Acid phosphatase activity (mean and standard error for six samples) for *Microcystis aeruginosa* and *Oscillatoria simplicissima* initially (B = before treatment) and after (A = after treatment) being exposed to varying N:P ratios (External control = EM medium).

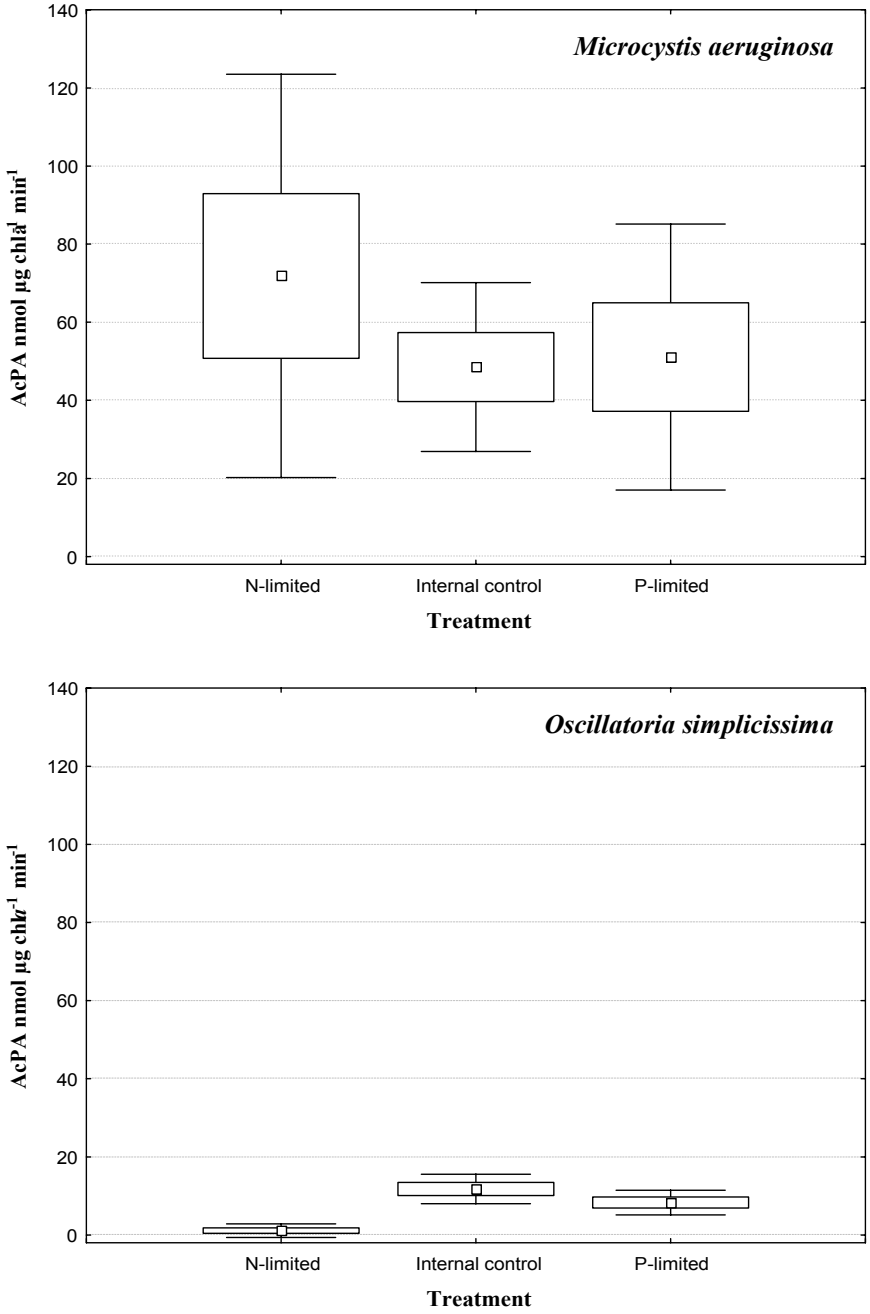


Figure 3.11. Specific acid phosphatase activity of *Microcystis aeruginosa* and *Oscillatoria simplicissima* at the end of the experiment in the three experimental treatments. Averages marked by rectangle, boxes include standard error and whiskers mark standard deviation, n = 6 in each treatment.

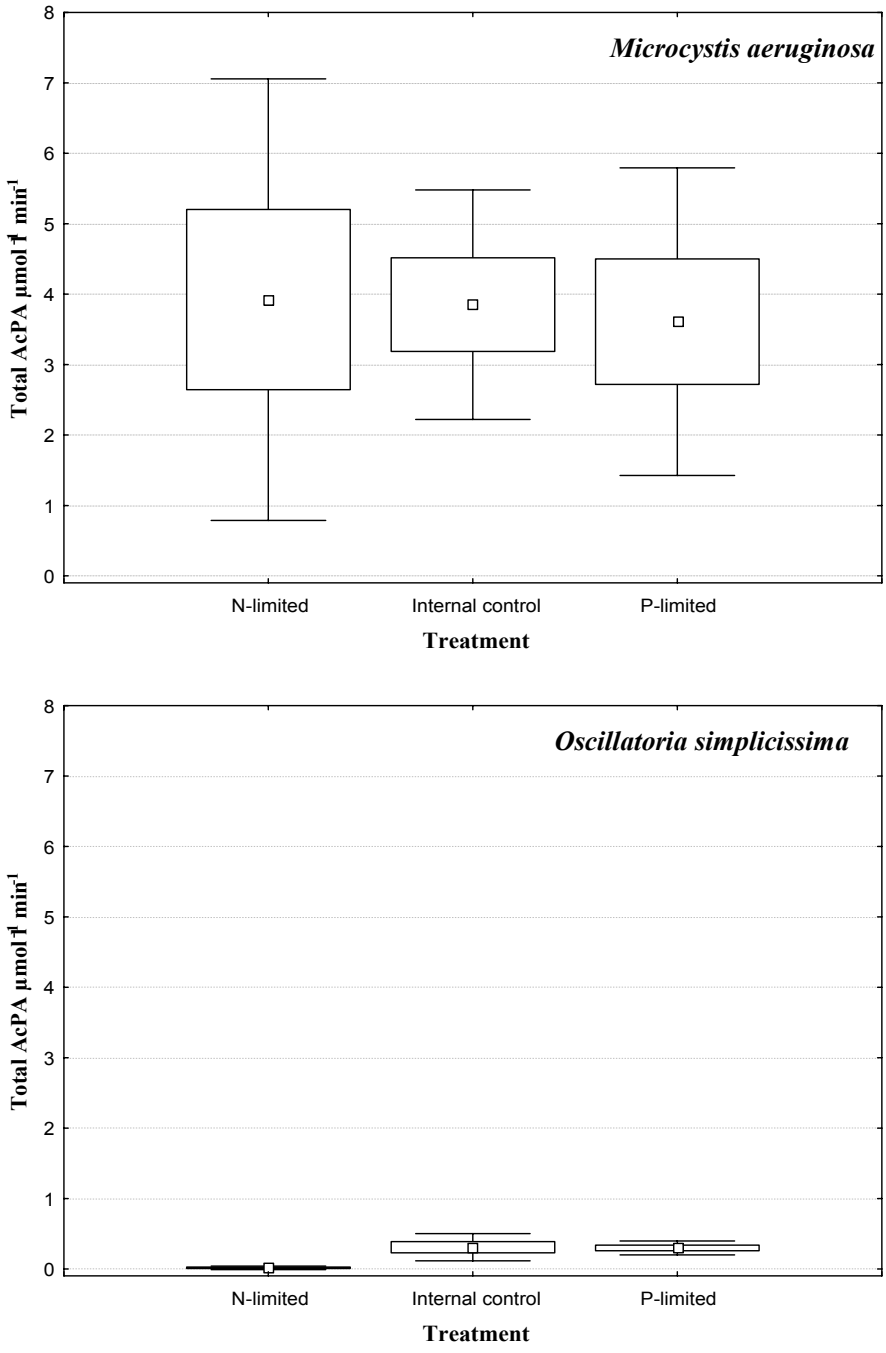


Figure 3.12. Total acid phosphatase activity of *Microcystis aeruginosa* and *Oscillatoria simplicissima* at the end of the experiment in the three experimental treatments. Averages marked by rectangle, boxes include standard error and whiskers mark standard deviation, n = 6 in each treatment.

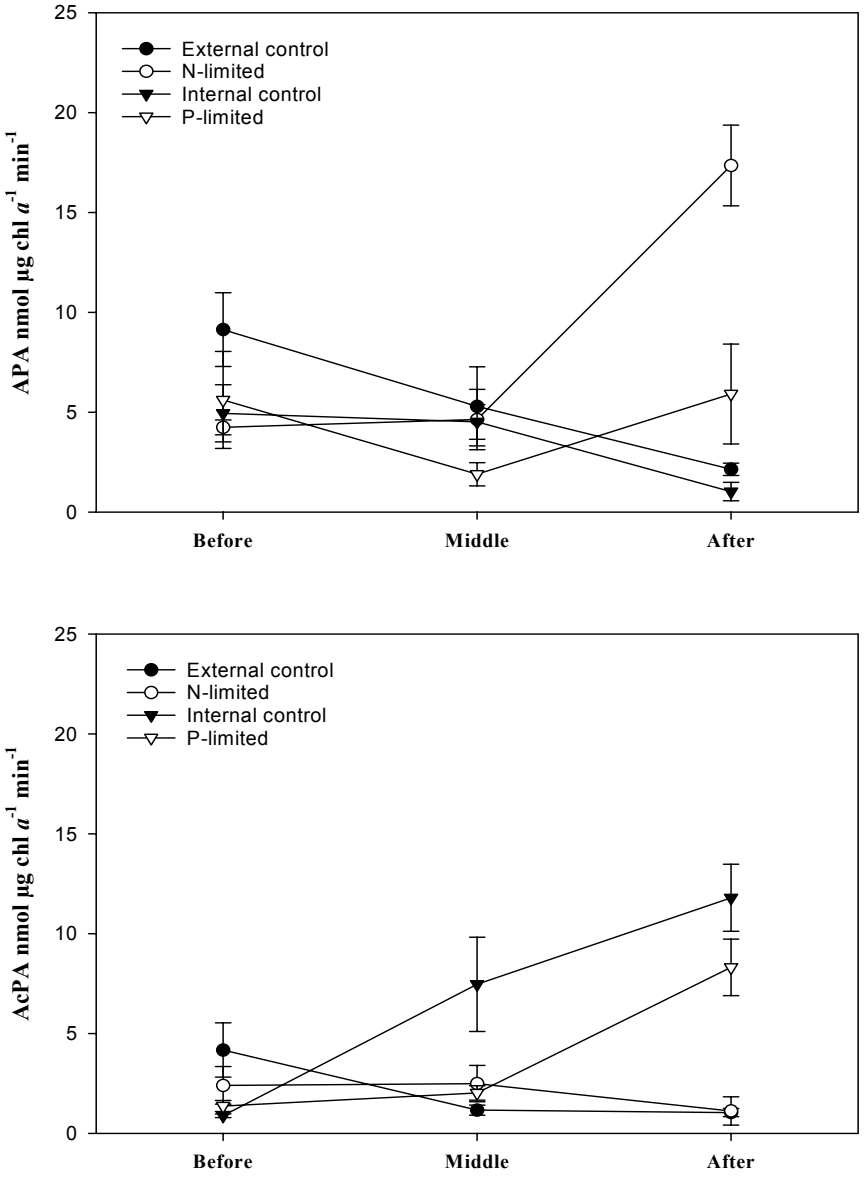


Figure 3.13. Alkaline (APA, figure above) and acid (AcPA, figure below) phosphatase activity (mean and standard error, n = 6) in *Oscillatoria simplicissima* before the dilutions started (before), halfway through the experiments (Middle) and when steady state was reached (after).

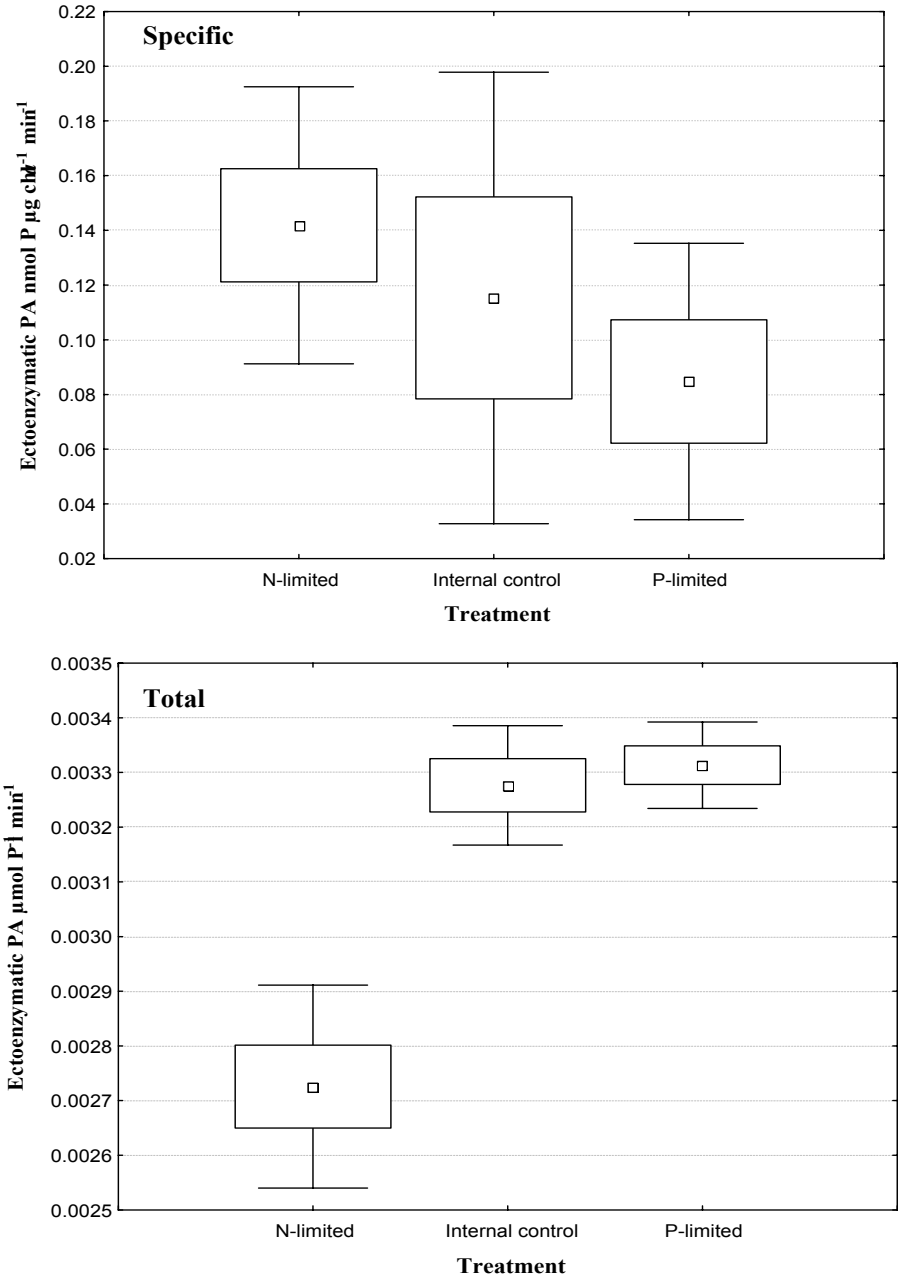


Figure 3.14. Specific and total ectoenzymatic phosphatase activity (middle point indicates mean, box value standard error and whisker value standard deviation, n = 6 in each treatment) of *Oscillatoria simplicissima* at the end of the experiment in the three different experimental treatments.

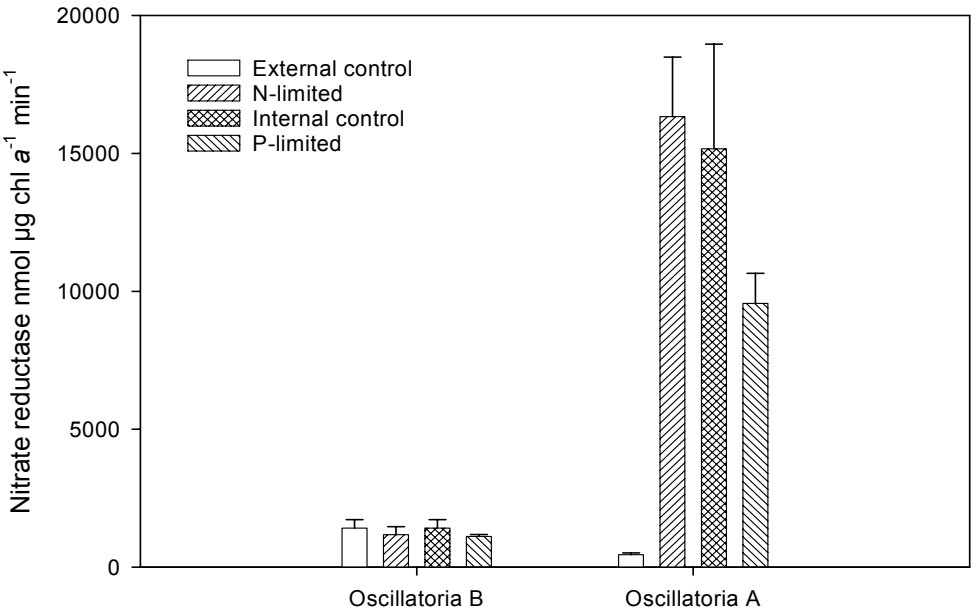


Figure 3.15. Specific nitrate reductase (mean and standard error for six samples) in Oscillatoria simplicissima initially (B = before treatment) and after (A = after treatment) being exposed to varying N:P ratios (External control = EM medium).

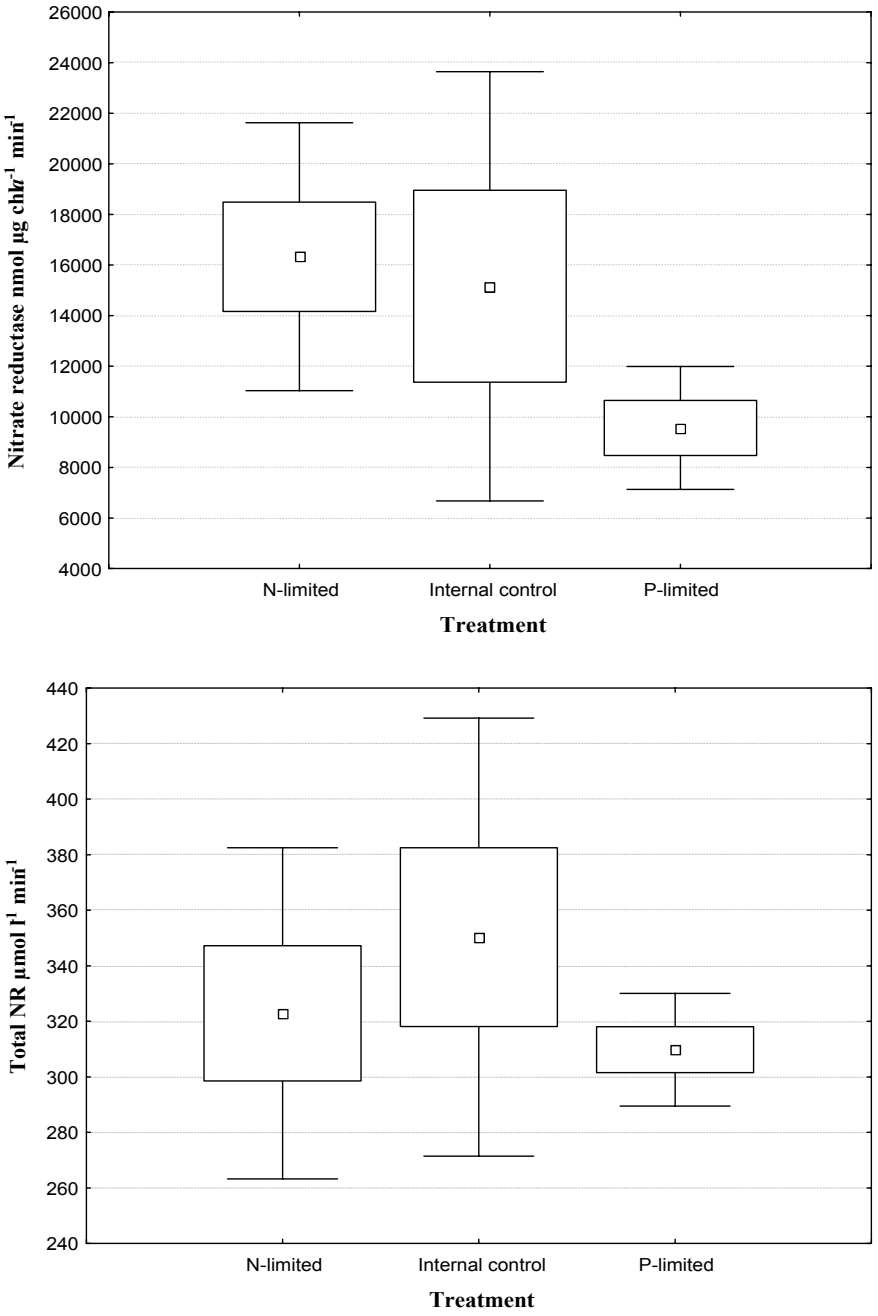
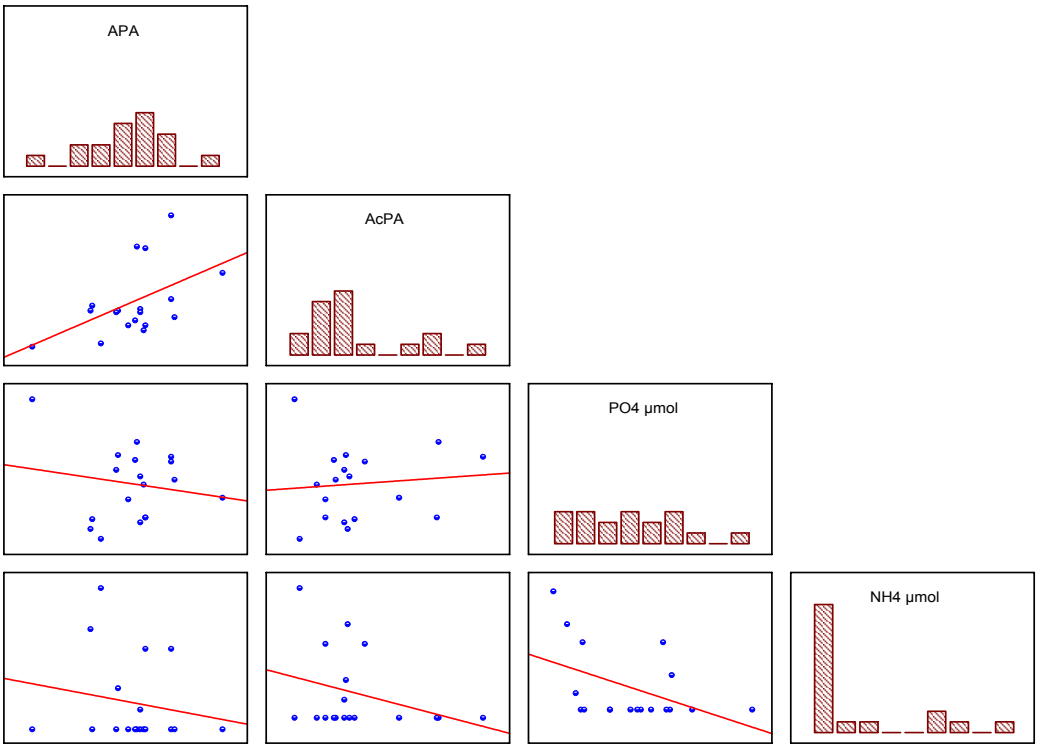


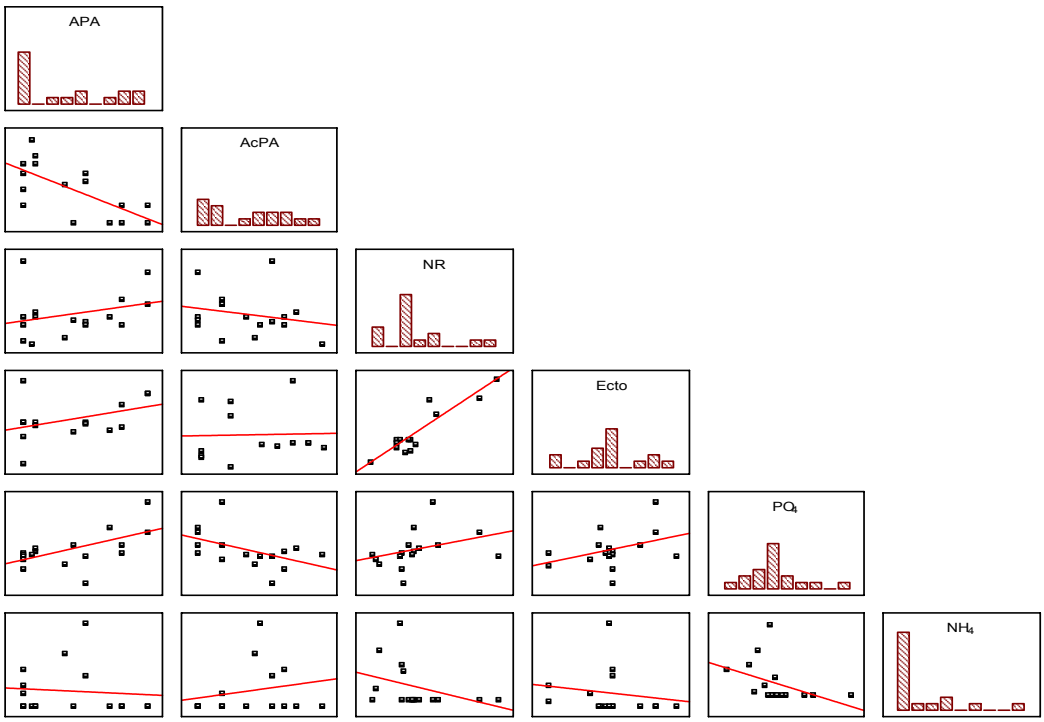
Figure 3.16. Specific and total nitrate reductase (middle point indicates mean, box value standard error and whisker value standard deviation, n = 6 in each treatment) of *Oscillatoria simplicissima* at the end of the experiment in the three different experimental treatments.



	APA	AcPA	PO4	NH4
APA	1.0000			
AcPA	***0.5***	1.0000		
PO4	-0.17	0.1	1.0000	
NH4	-0.17	-0.32	-0.45	1.0000

Figure 3.17 and Table 3.5. Presence and absence of correlation between the measured enzyme activities and chemical variables in the three experimental treatments in *Microcystis aeruginosa* sp. at the end of the experiment. Scatterplots present the variables shown (as histograms presenting the distribution of the data) on top and to the right of each plot. Spearman correlation coefficients (R, n = 18) are given in the table,

statistically significant ($p < 0.05$) values are indicated with bold italic numbers.



	APA	AcPA	NR	Ecto	PO_4	NH_4
APA	1.0000					
AcPA	***-0.6256***	1.0000				
NR	0.3311	-0.2394	1.0000			
Ecto	0.3358	0.2029	***0.7026***	1.0000		
PO_4	***0.6034***	***-0.5413***	***0.5752***	0.1708	1.0000	
NH_4	-0.2459	0.2582	***-0.6017***	-0.2976	***-0.7250***	1.000

Figure 3.18 and Table 3.6. Presence and absence of correlation between the measured enzyme activities and chemical variables in the three experimental treatments in *Oscillatoria simplicissima* at the end of the experiment. Scatterplots present the variables shown (as histograms presenting the distribution of the data) on top and to the right of each plot. Spearman correlation coefficients (R, n = 18) are given in the table, statistically significant ($p < 0.05$) values are indicated with bold italic numbers.

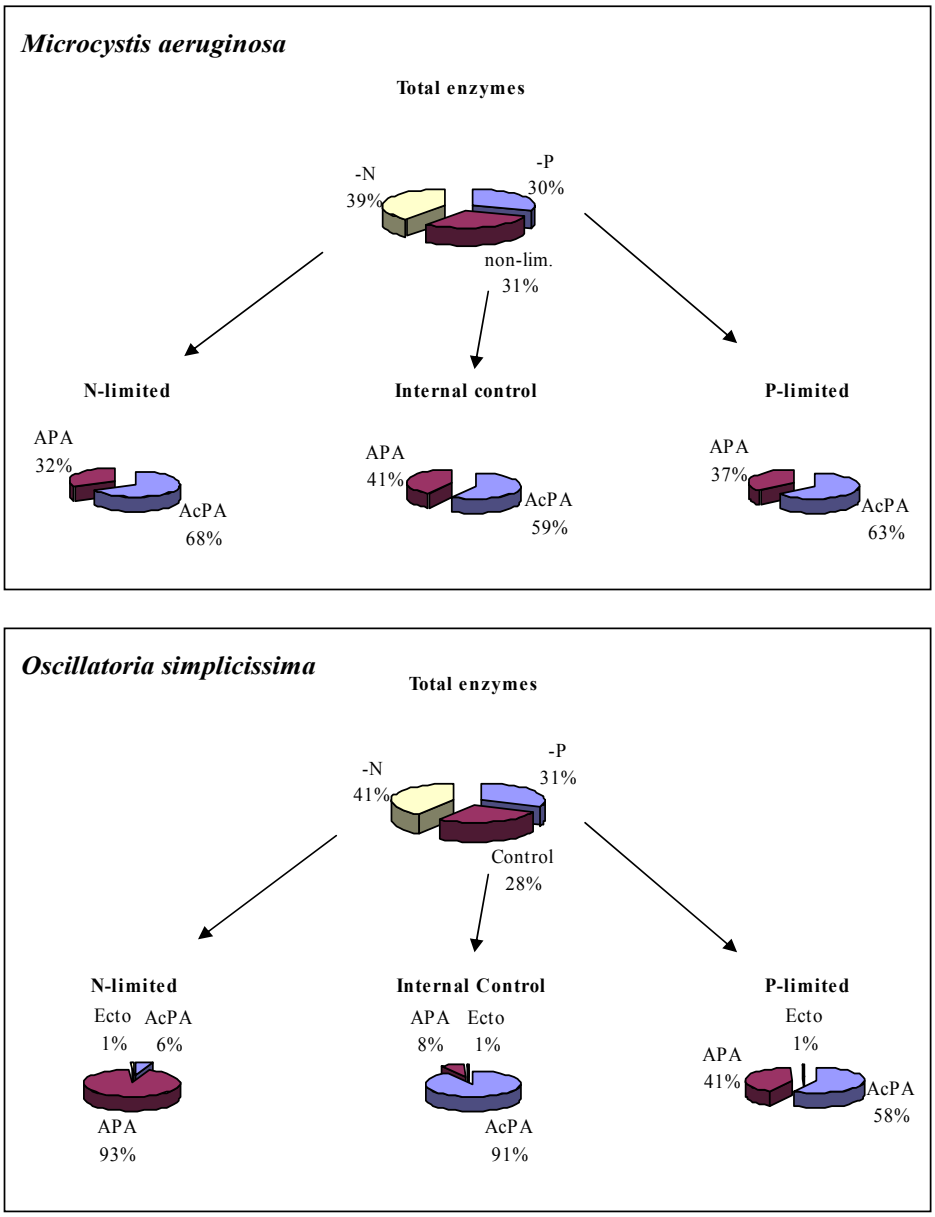
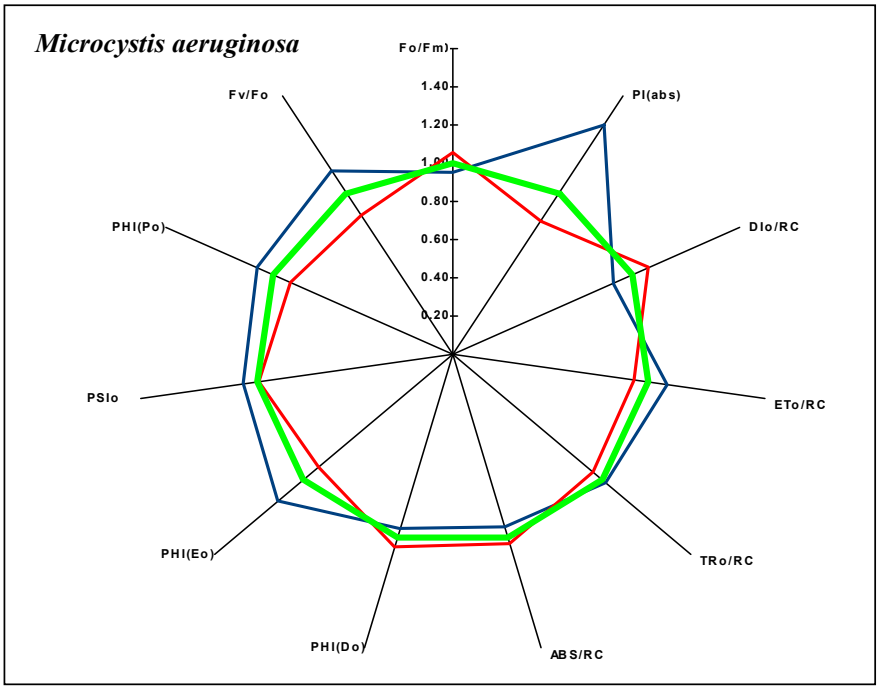


Figure 3.19. Percentage distribution of total enzyme activity (APA, AcPA and ectoenzymatic phosphatase activity (*Oscillatoria simplicissima* only)) in the different treatments, and percentage distribution of enzyme type in each treatment in *Microcystis aeruginosa* (above) and *Oscillatoria simplicissima* (below).



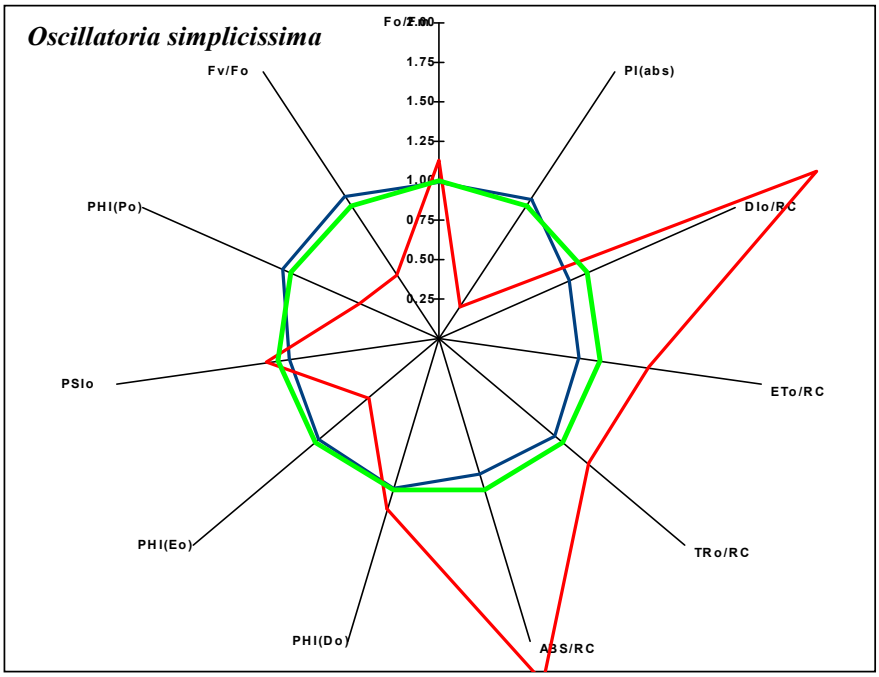


Figure 3.20. Flux ratios, specific energy fluxes and vitality of PSII functions in *Microcystis aeruginosa* and *Oscillatoria simplicissima* grown in different N:P ratios. Red line = N-limited treatment, blue line = P-limited treatment and green line = Internal control.

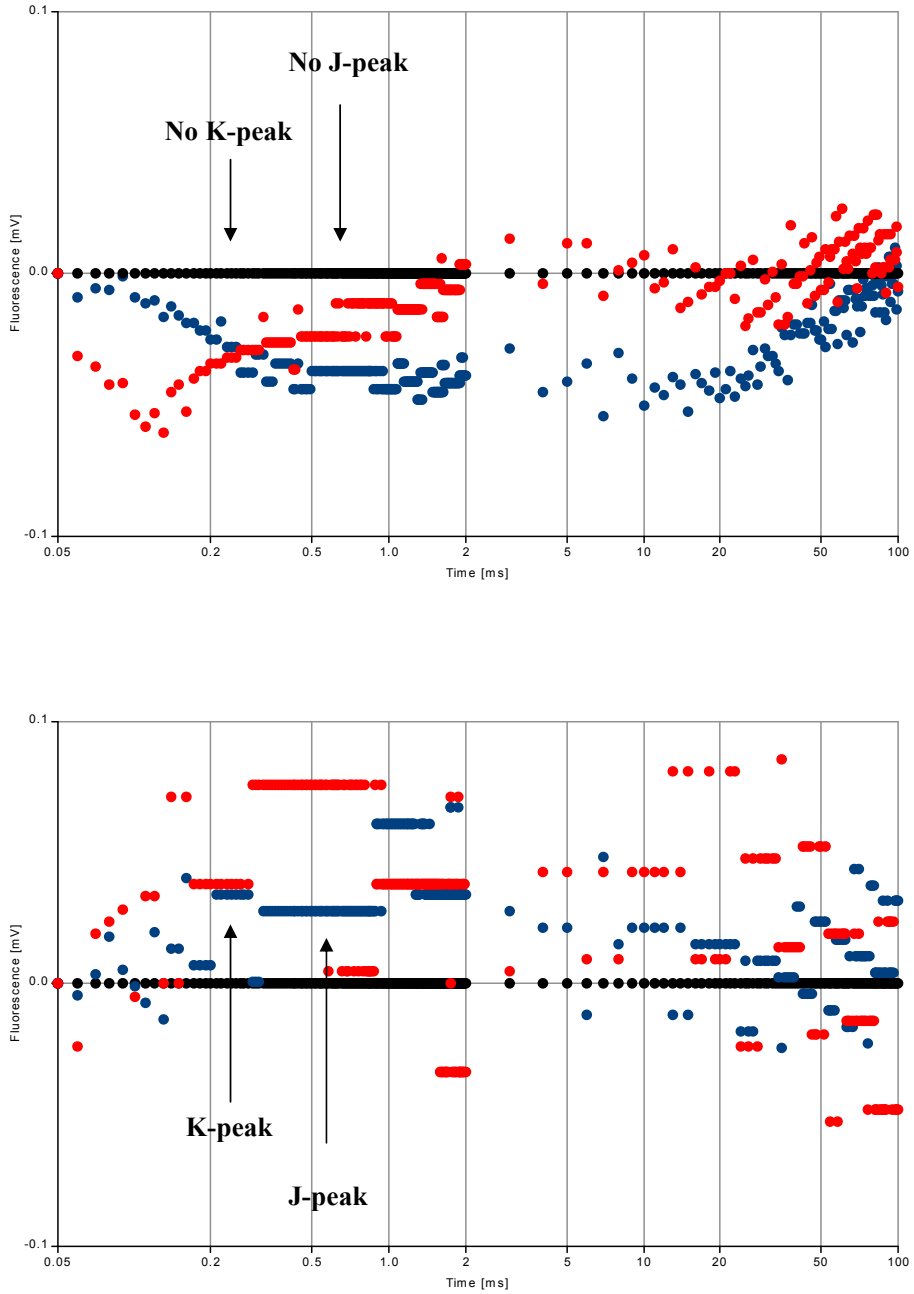


Figure 3.21. Normalised fluorescence rise curves (N (red dots) and P-limited (blue dots) treatments as compared to the internal control, deviation from internal control (Black dots) on y-axis) demonstrating the presence of a J and K-peak in *Oscillatoria simplicissima*, whereas no such peaks were present in *Microcystis aeruginosa*.

CHAPTER 4

COMPARISON OF THE GROWTH DYNAMICS OF THE CYANOBACTERIA MICROCYSTIS AERUGINOSA KÜTZING EMEND ELENKIN (1846) AND OSCILLATORIA SIMPLICISSIMA GOMONT (1982) AT DIFFERENT TEMPERATURES, LIGHT INTENSITIES AND N:P RATIOS

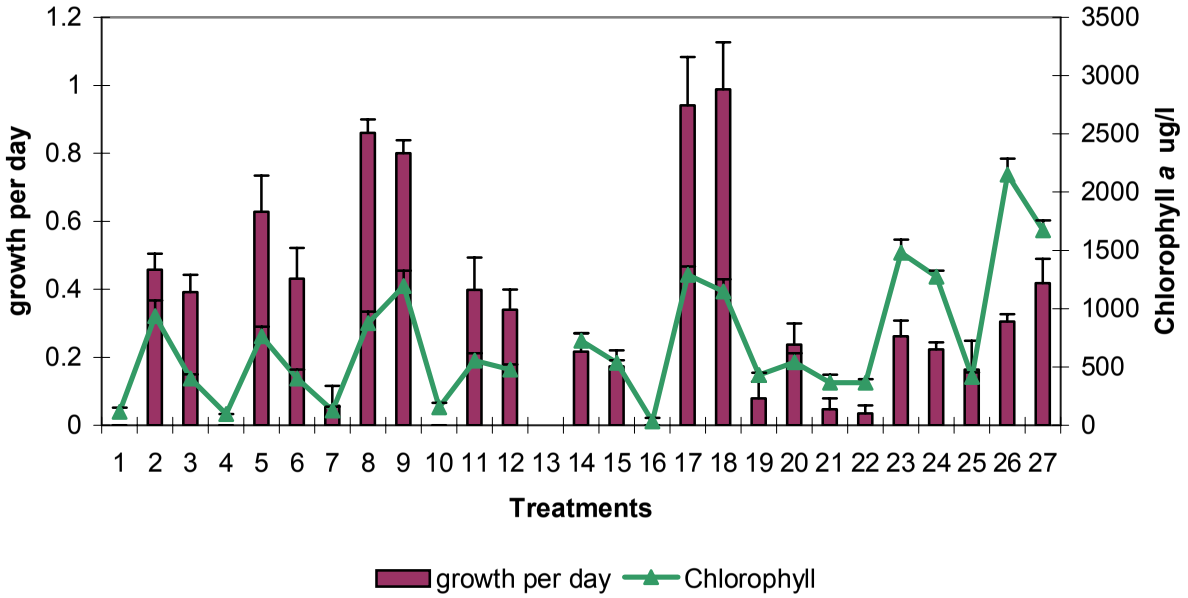


Figure 4.1**:** Comparison of the growth rates per day and the chlorophyll-*a* of the different treatments of *Microcystis aeruginosa.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

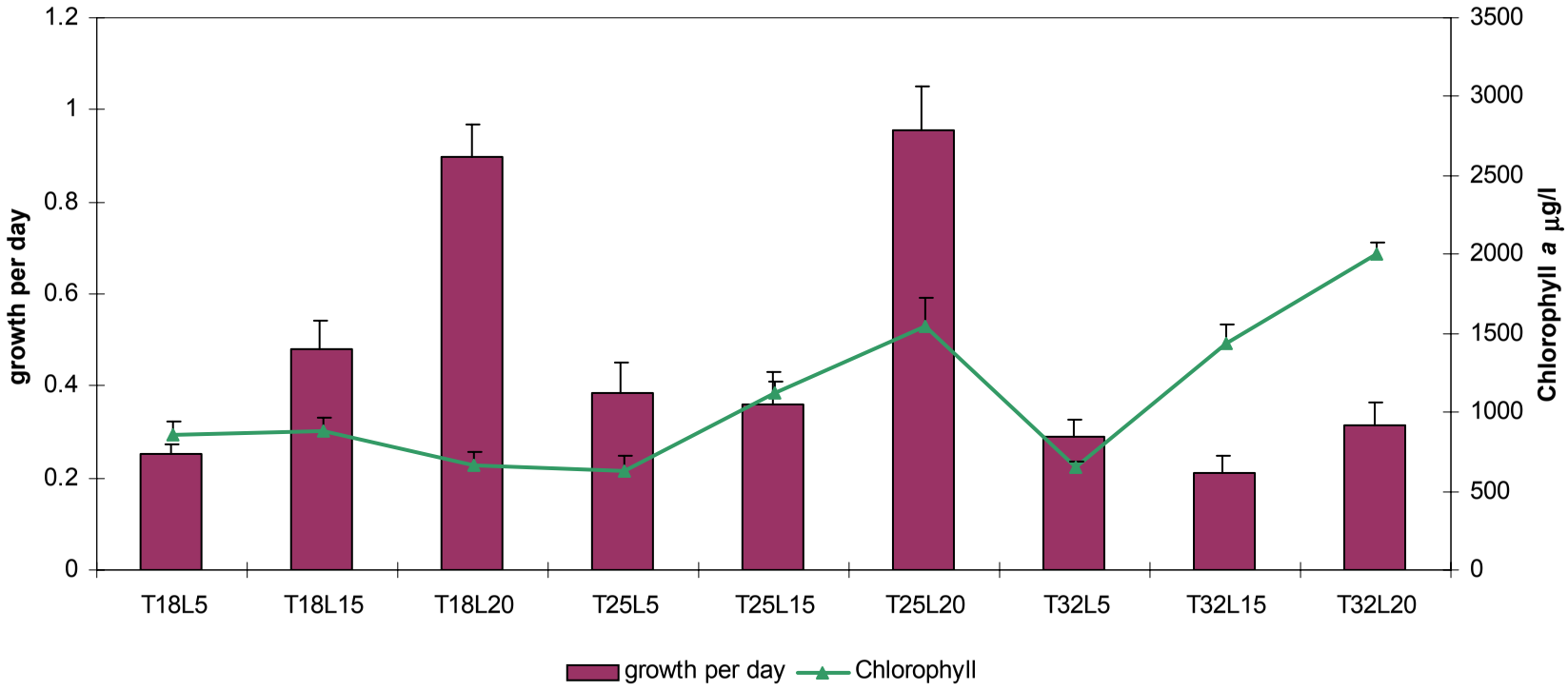


Figure 4.2**:** Comparison of the growth rates per day and the chlorophyll-*a* of the external control of *Microcystis aeruginosa*.

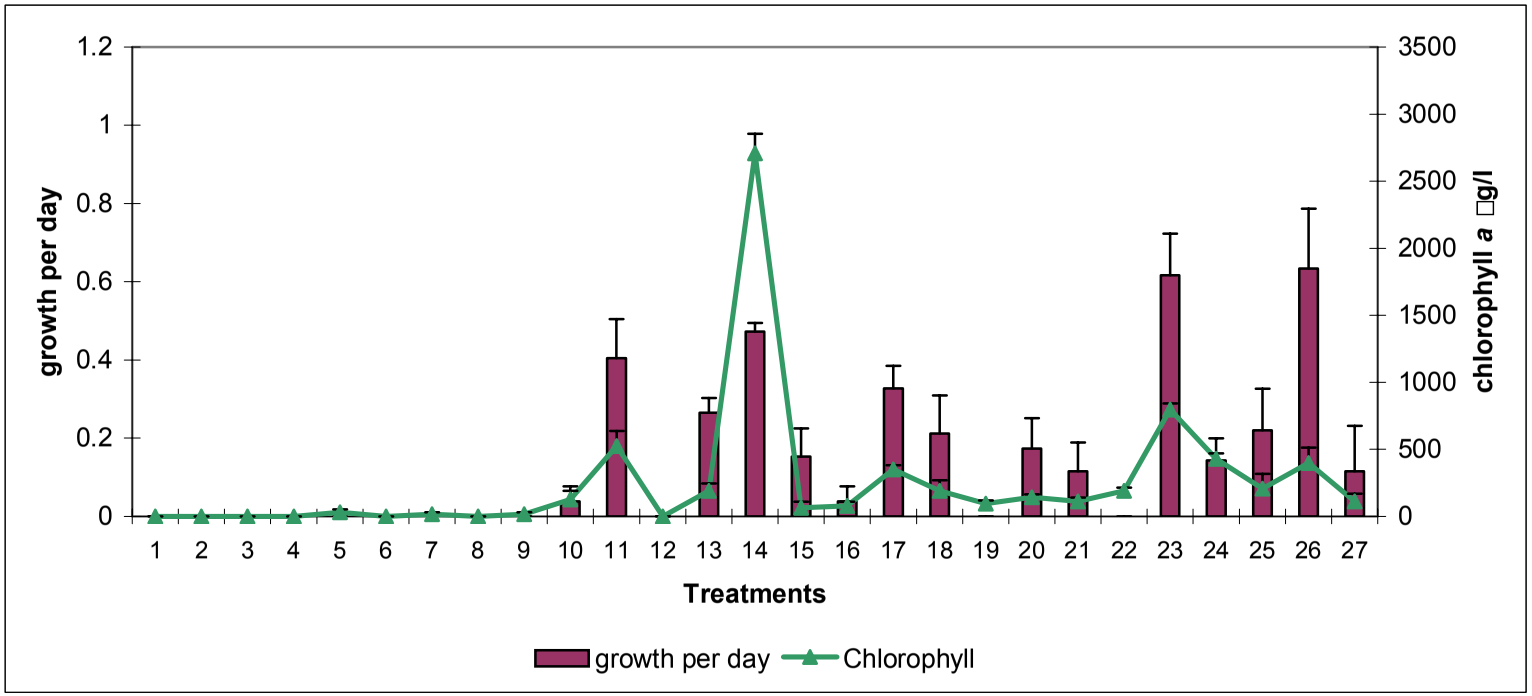


Figure 4.3**:** Comparison of the growth rates per day and the chlorophyll-*a* of the different treatments of *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

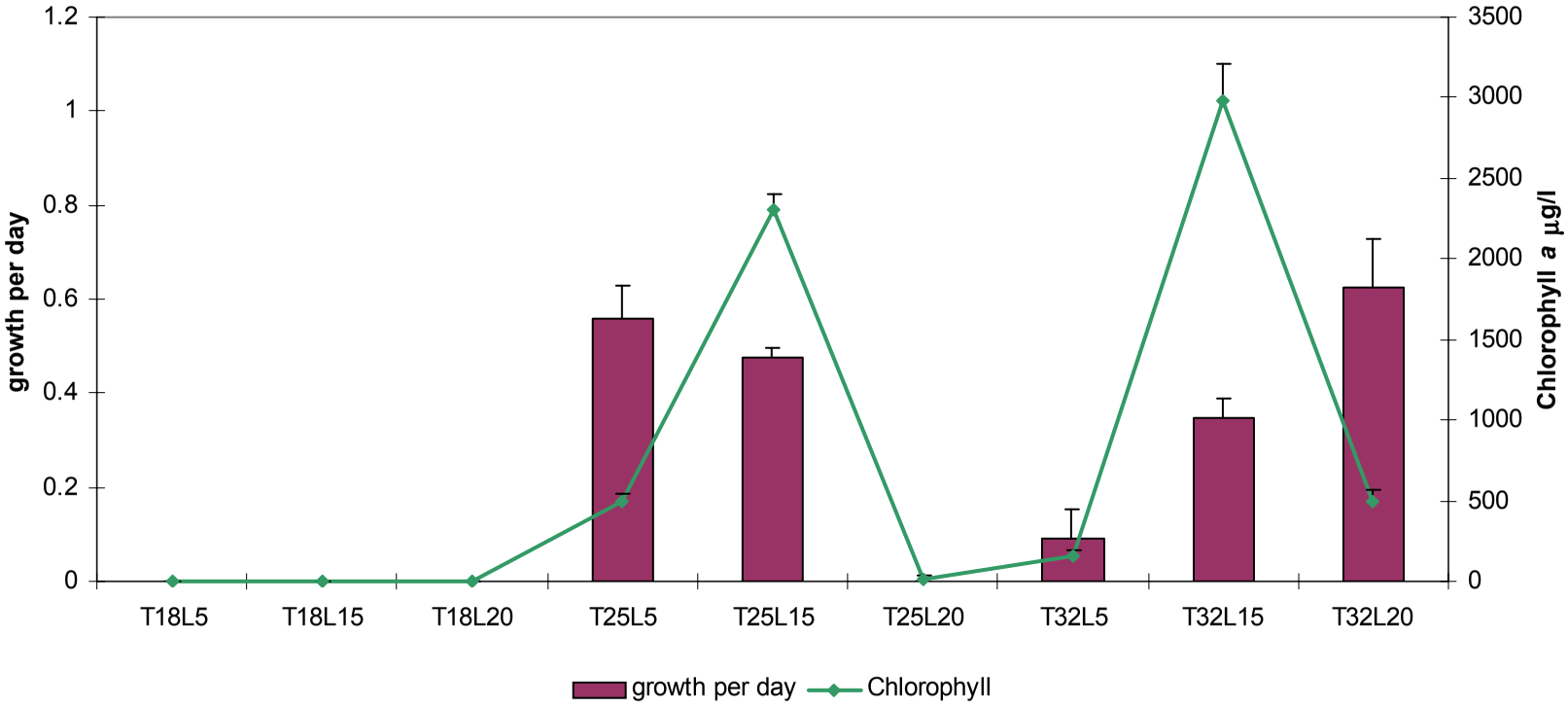


Figure 4.4**:** Comparison of the growth rates per day and the chlorophyll-*a* of the external control of *Oscillatoria simplicissima.*

CHAPTER 5

COMPARISON OF THE PHOSPHATASE ACTIVITY OF THE CYANOBACTERIA MICROCYSTIS AERUGINOSA KÜTZING EMEND ELENKIN (1846) AND OSCILLATORIA SIMPLICISSIMA GOMONT (1982) AT DIFFERENT TEMPERATURES, LIGHT INTENSITIES AND N:P RATIOS

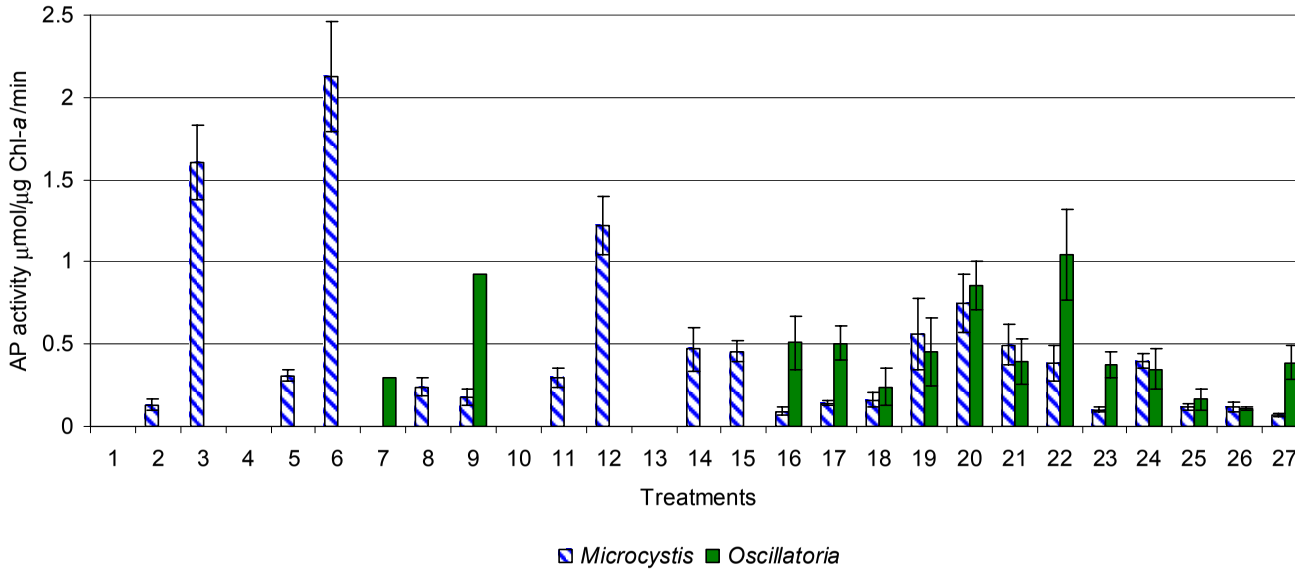


Figure 5.1: Comparison of the alkaline phosphatase activity (APA) of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments' numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

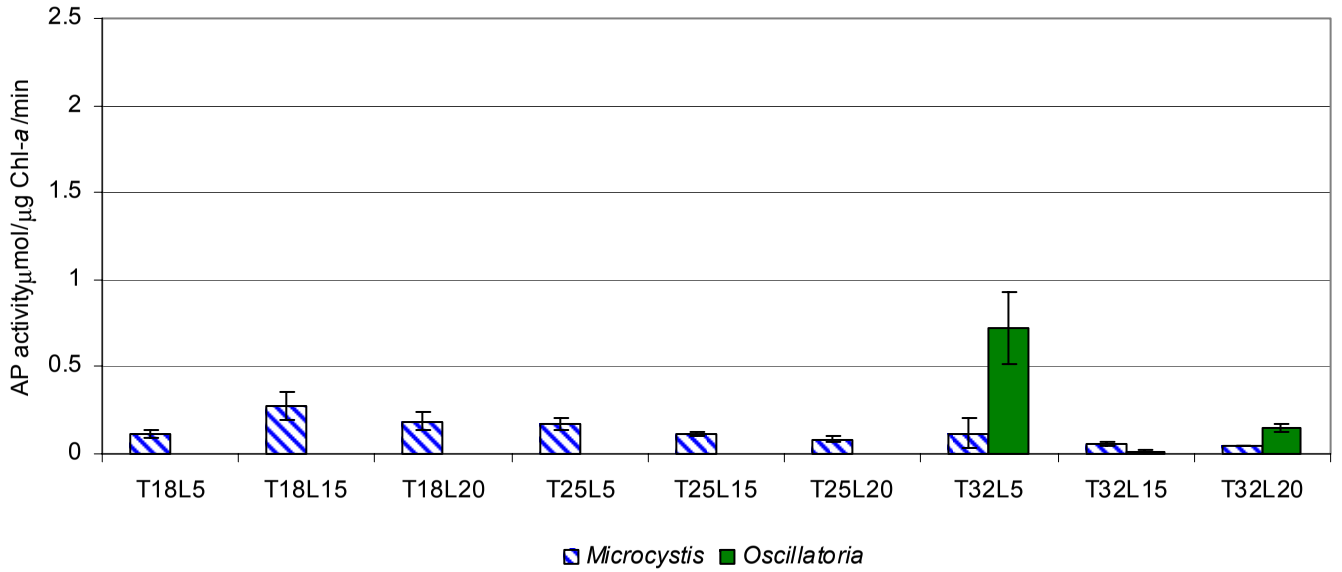


Figure 5.2: Comparison of the alkaline phosphatase activity (APA) of the external controls of *Microcystis aeruginosa* and *Oscillatoria simplicissima.*

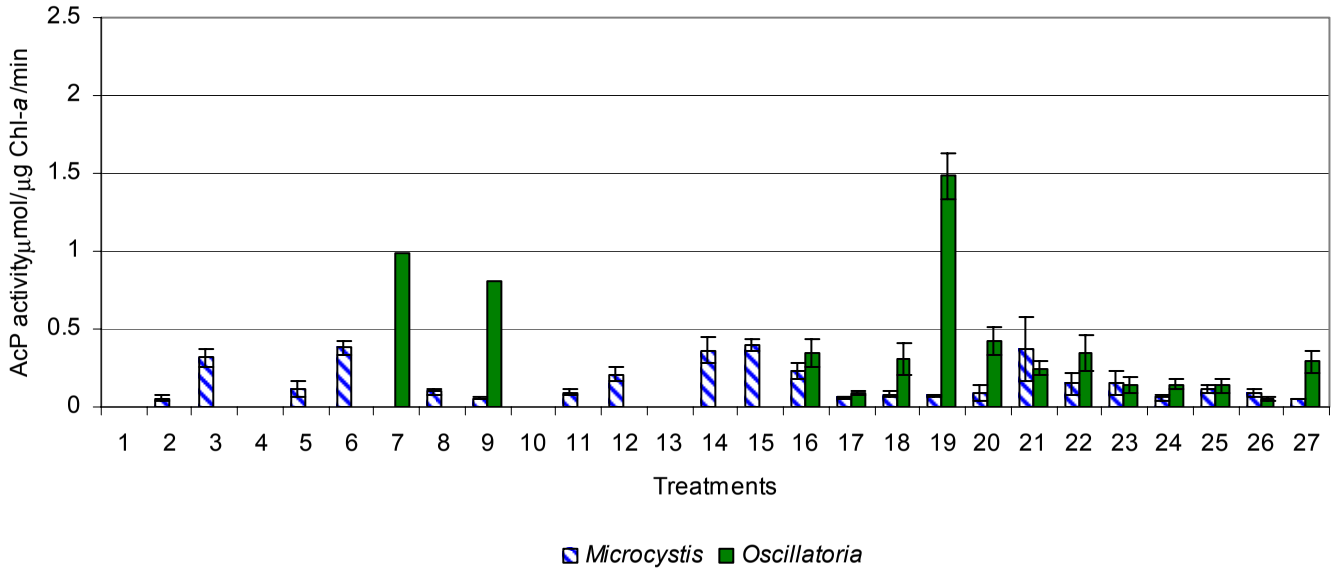


Figure 5.3: Comparison of the acid phosphatase activity (AcPA) of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

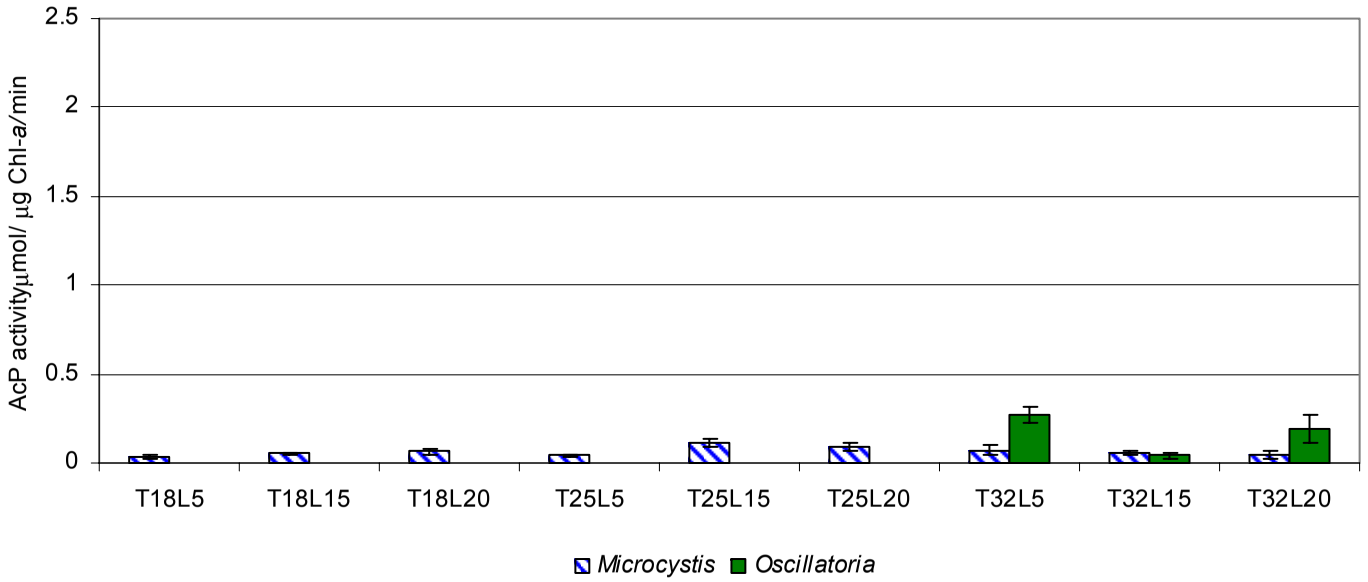


Figure 5.4: Comparison of the acid phosphatase activity (AcPA) of the external controls of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

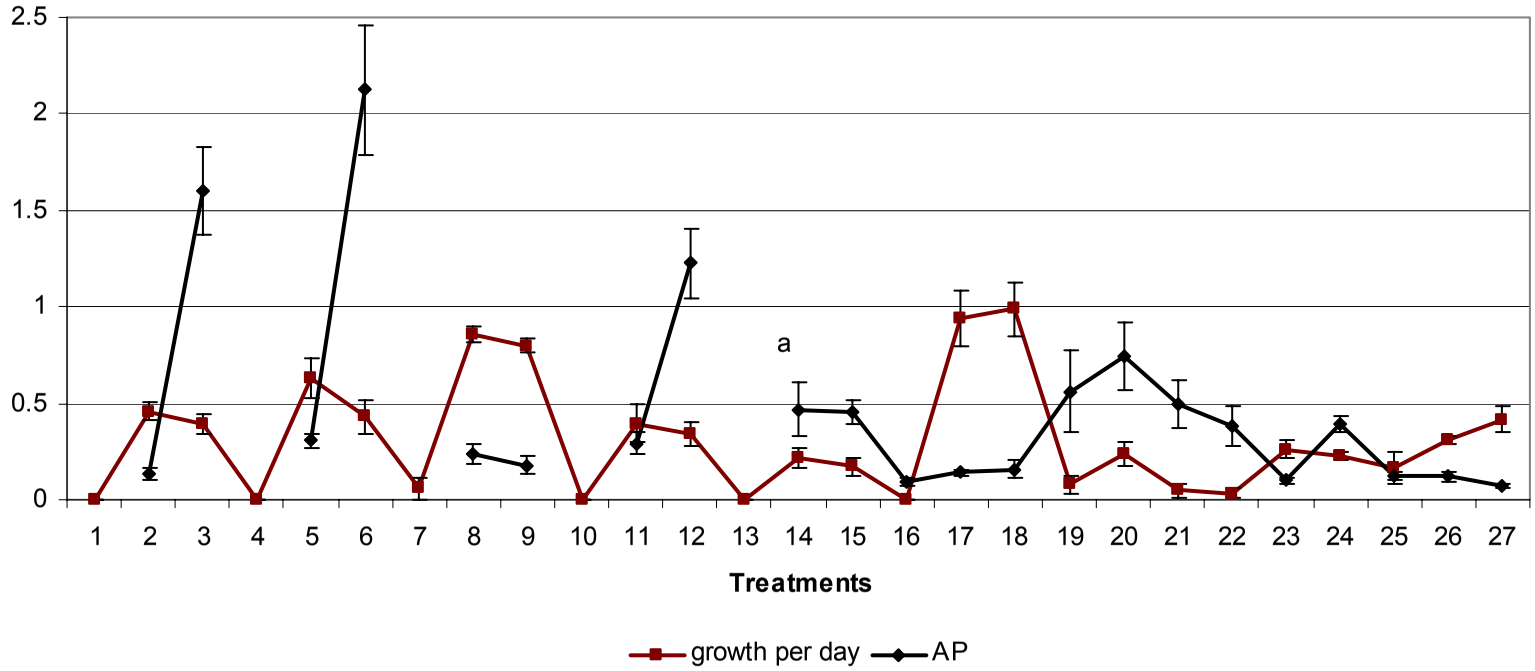


Figure 5.5**:** Comparison of the alkaline phosphatase activity (APA) and growth rate of *Microcystis aeruginosa.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

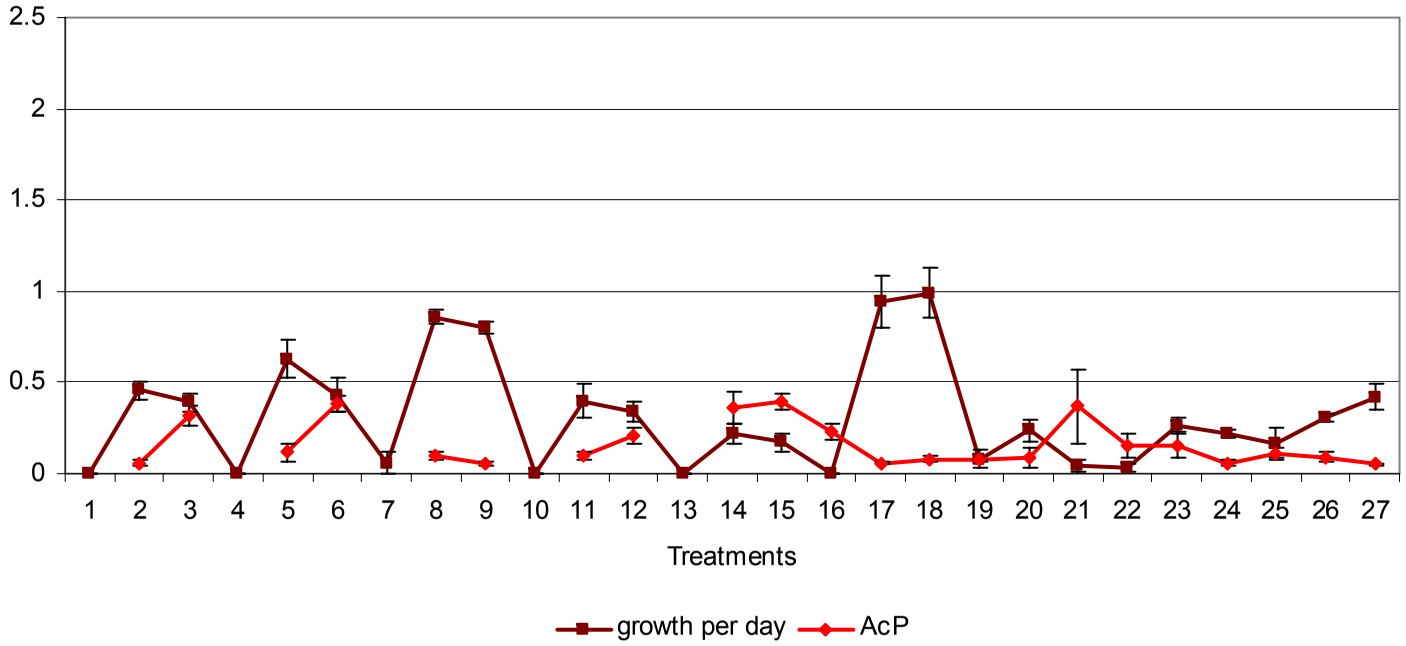


Figure 5.6: Comparison of the acid phosphatase activity (AcPA) and growth rate of *Microcystis aeruginosa.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

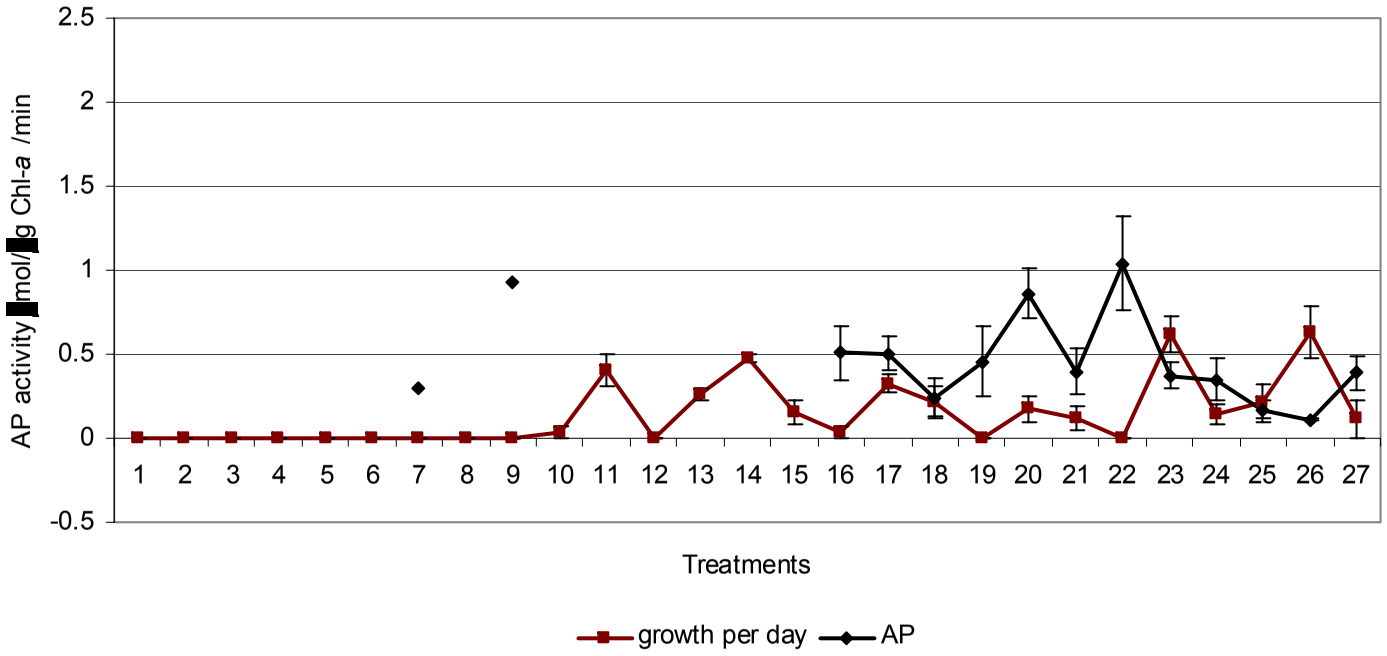


Figure 5.7: Comparison of the alkaline phosphatase activity (APA) and growth rate of *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

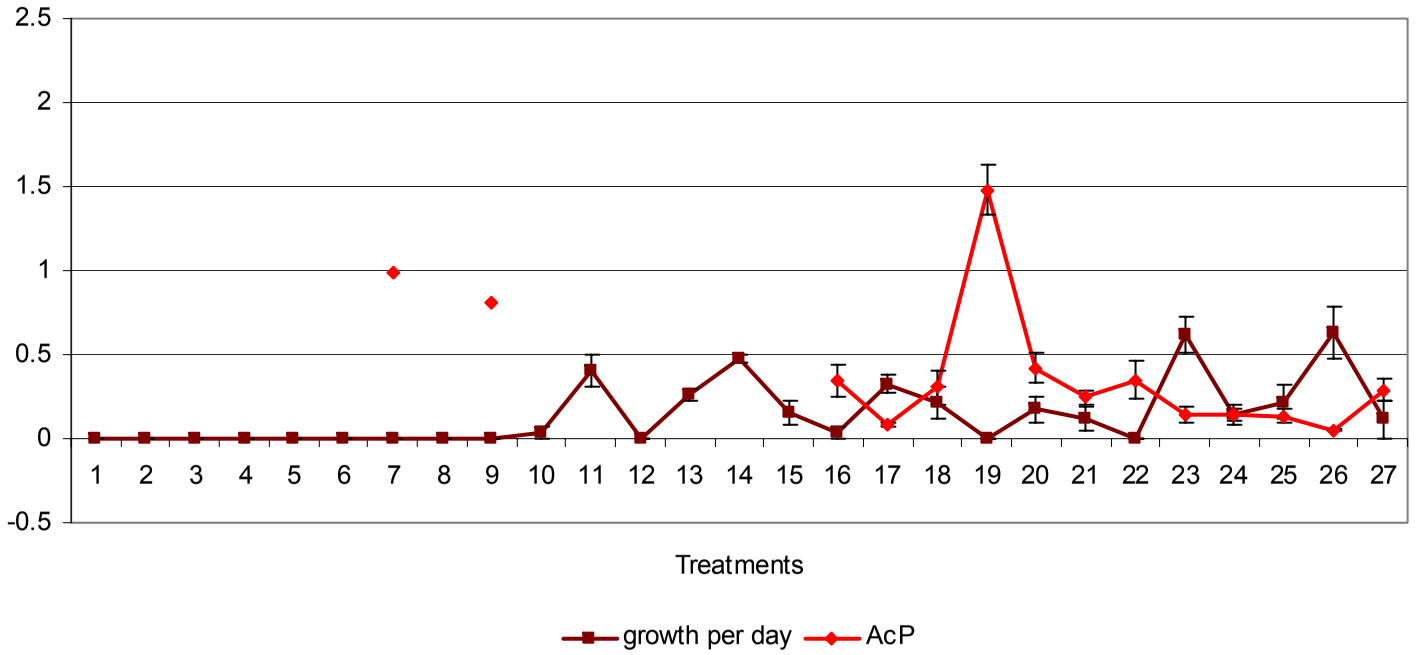


Figure 5.8: Comparison of the acid phosphatase activity (AcPA) and growth rate of *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

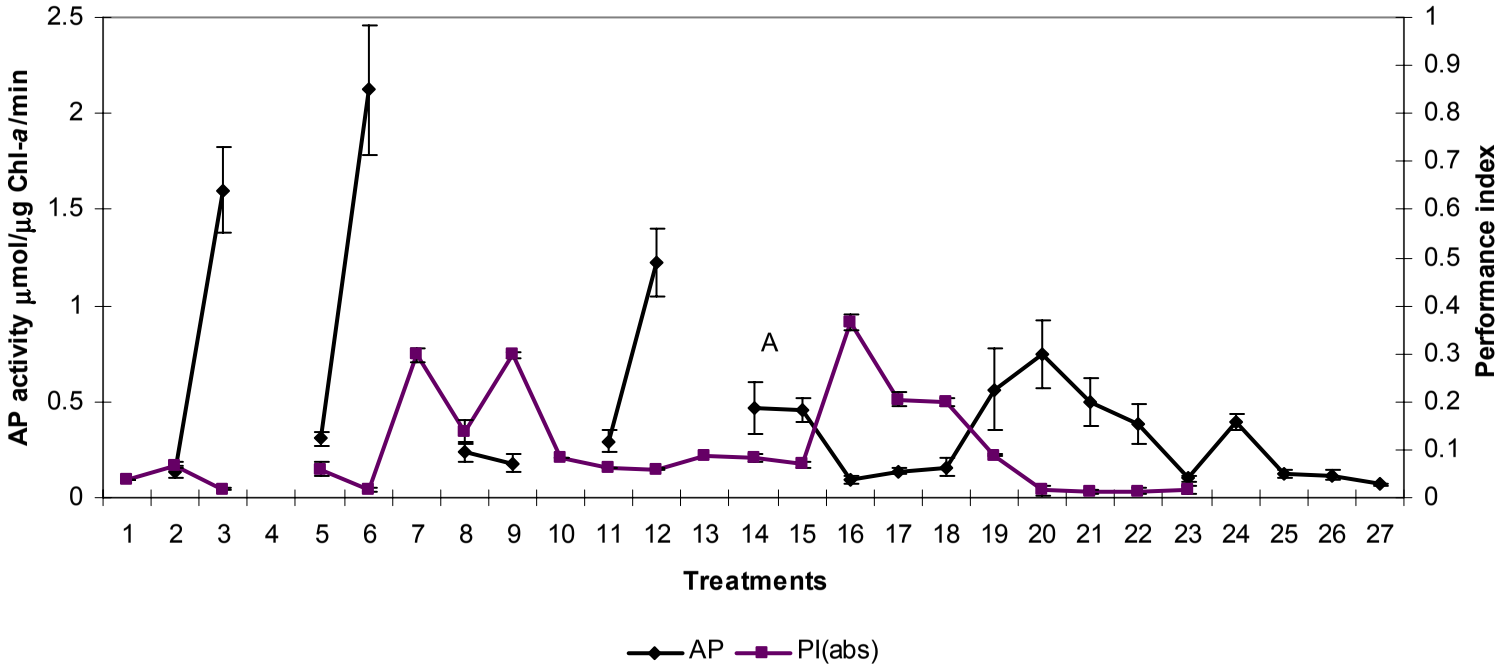


Figure 5.9: Comparison of the alkaline phosphatase activity (APA) and performance index of *Microcystis aeruginosa.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

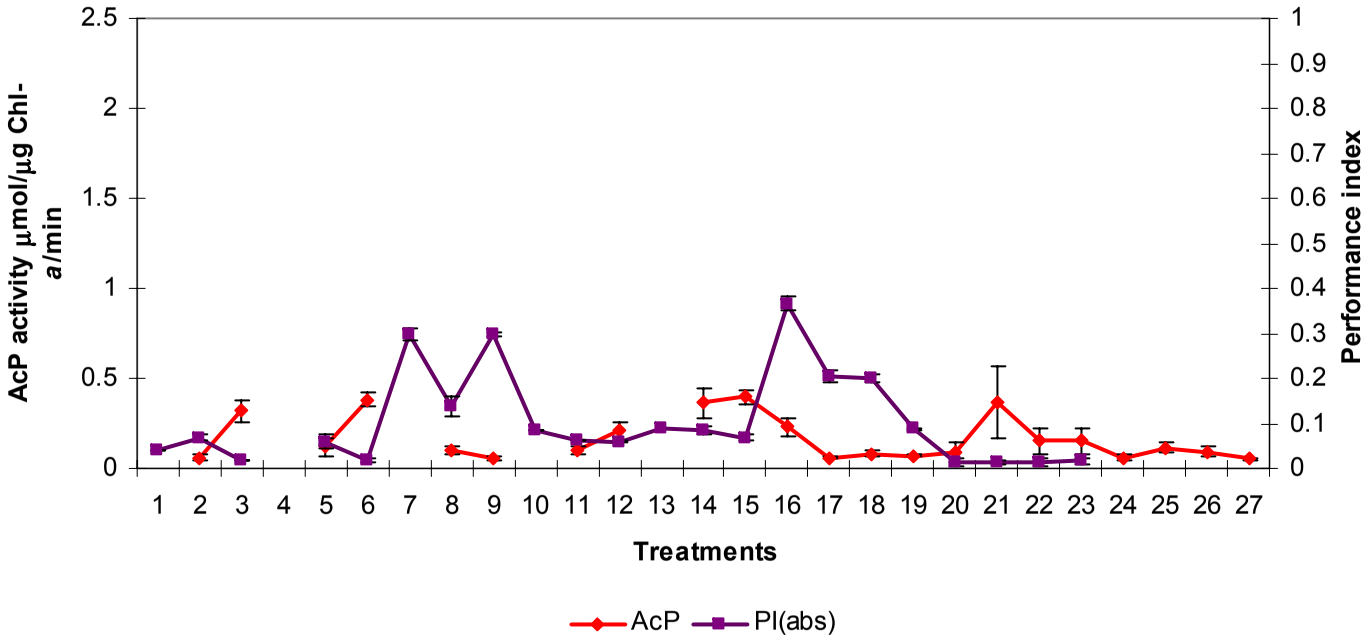


Figure 5.10: Comparison of the acid phosphatase activity (AcPA) and performance index of *Microcystis aeruginosa.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

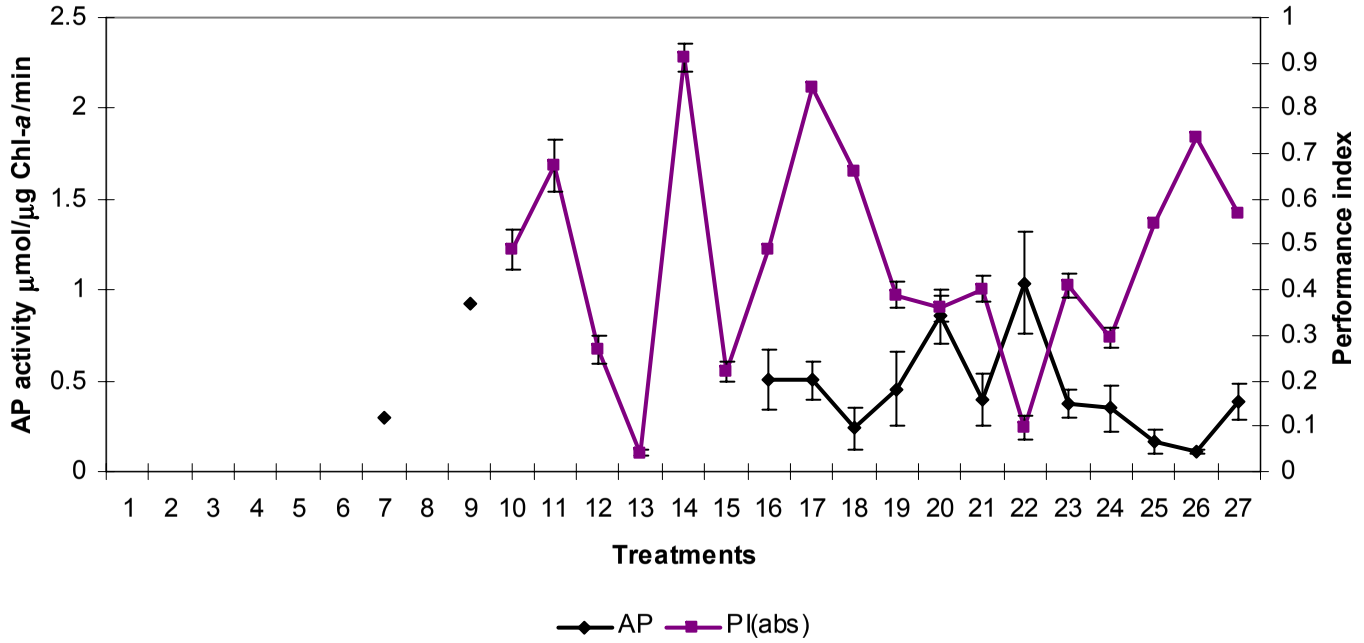


Figure 5.11: Comparison of the alkaline phosphatase activity (APA) and performance index of *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

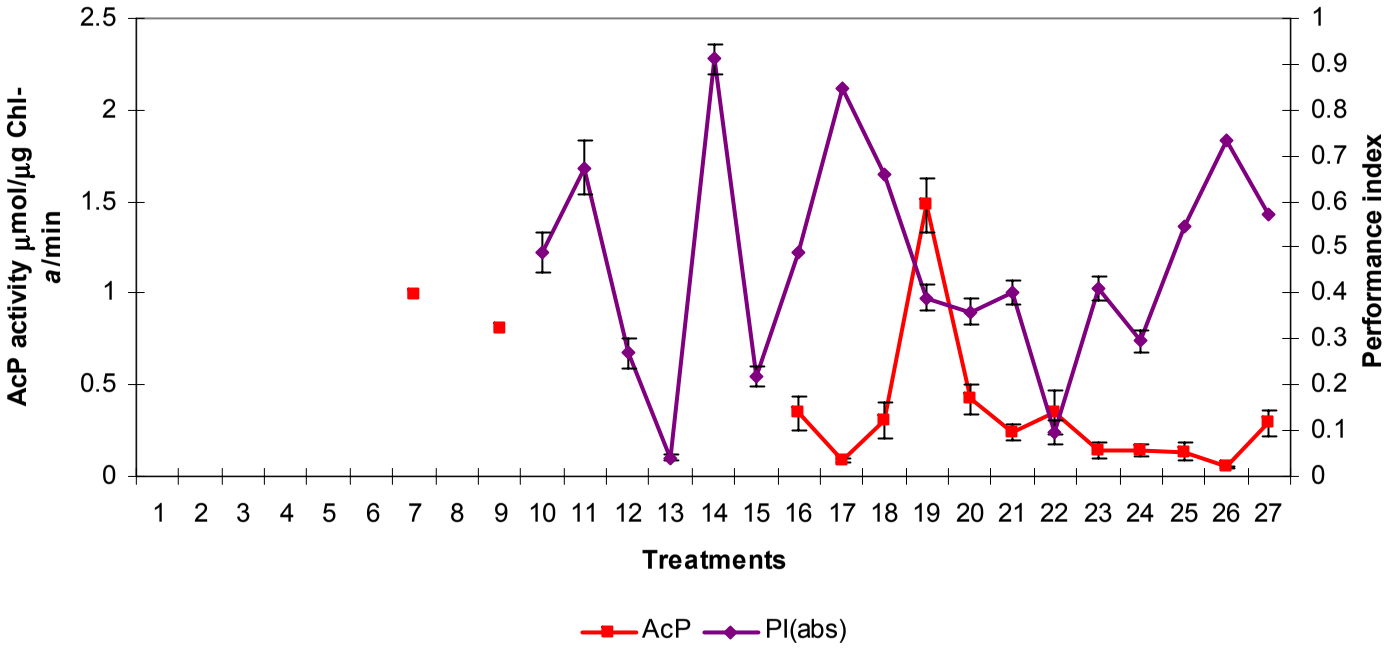


Figure 5.12: Comparison of the acid phosphatase activity (AcPA) and performance index of *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

CHAPTER 6

COMPARISON OF THE PHOTOSYNTHETIC PERFORMANCE OF THE CYANOBACTERIA MICROCYSTIS AERUGINOSA KÜTZING EMEND ELENKIN (1846) AND OSCILLATORIA SIMPLICISSIMA GOMONT (1982) AT DIFFERENT TEMPERATURES, LIGHT INTENSITIES AND N:P RATIOS

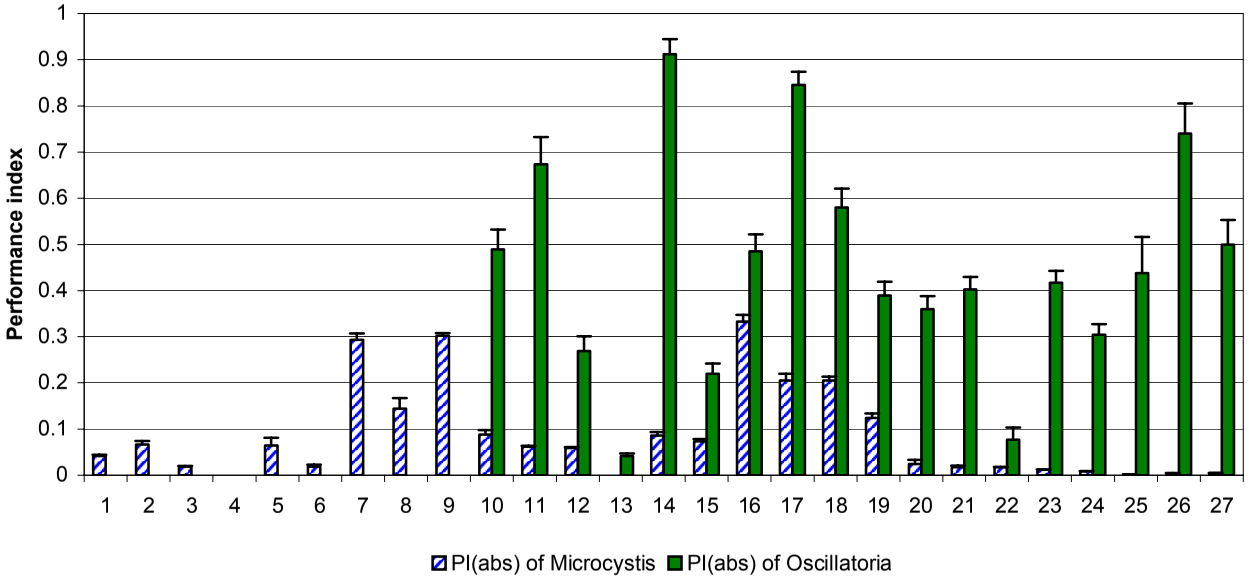


Figure 6.1: Comparison of the performance indexes the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

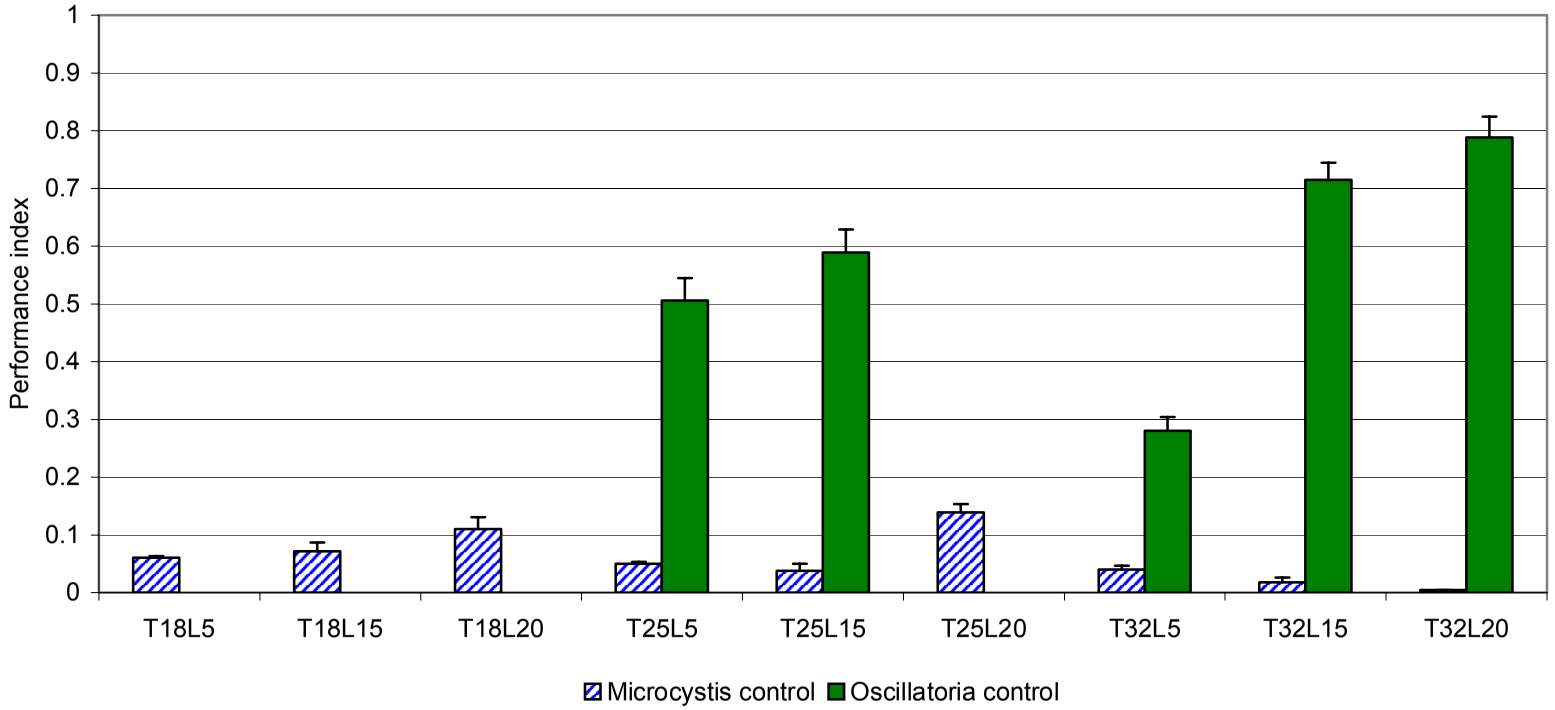


Figure 6.2: Comparison of the performance indexes the external controls of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

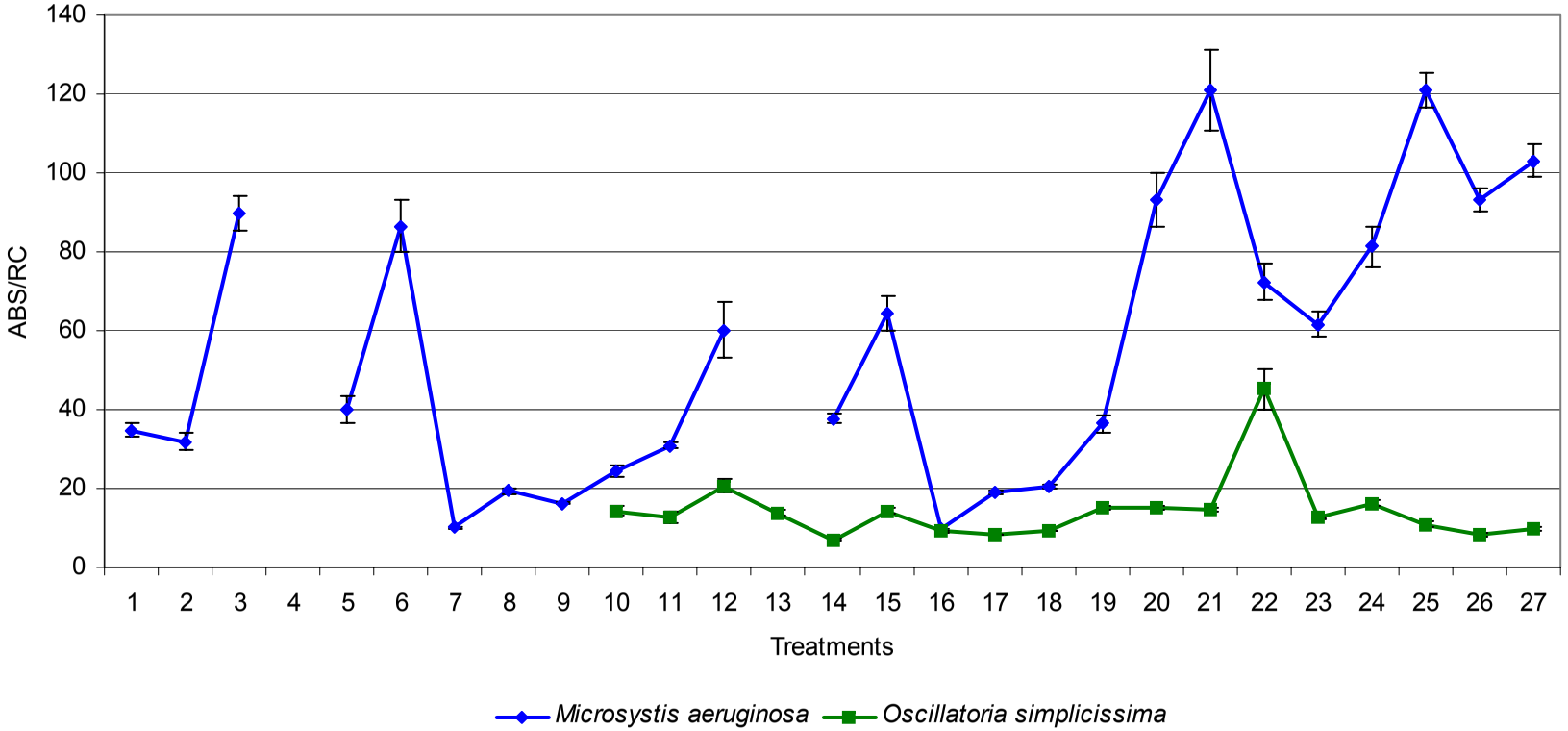


Figure 6.3: Comparison of the ABS/RC of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

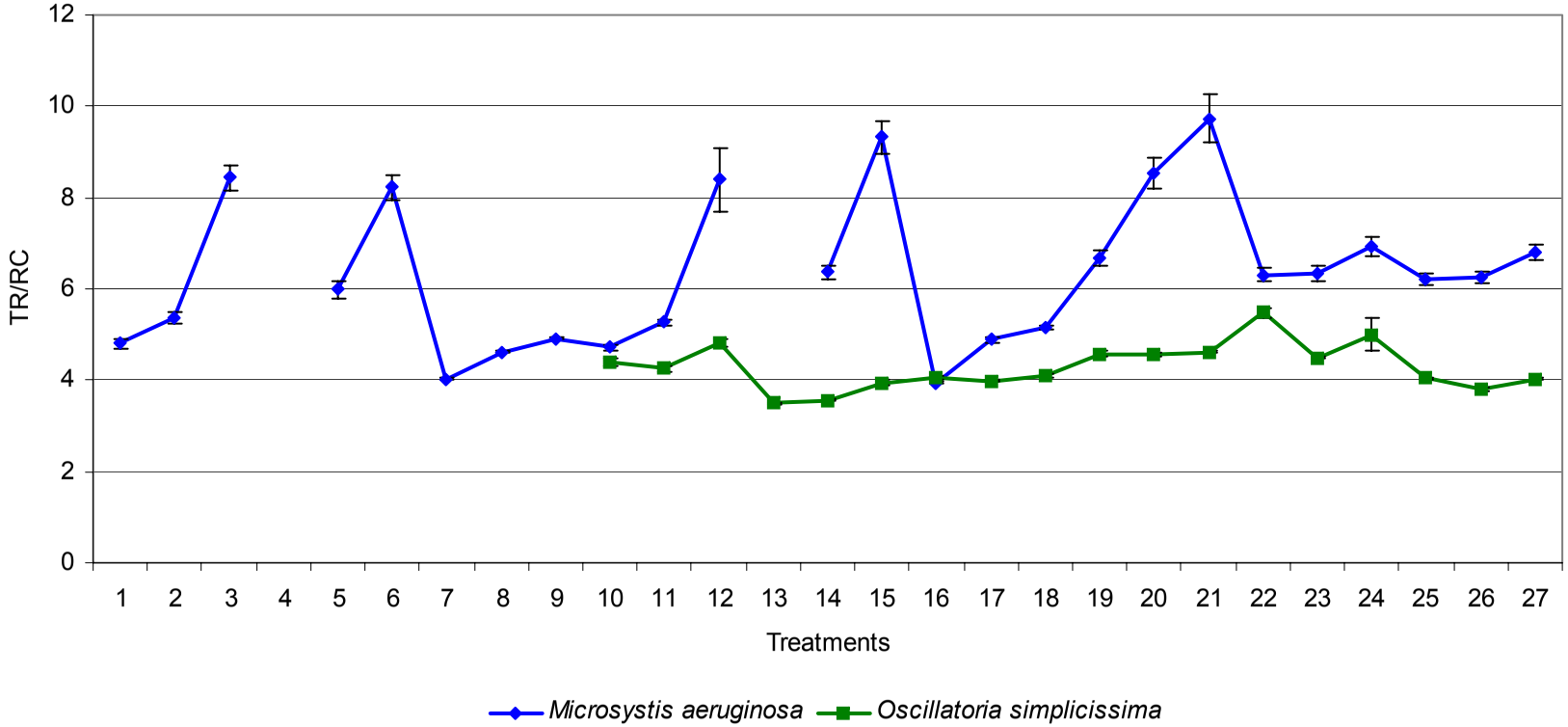


Figure 6.4: Comparison of the TR/RC of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

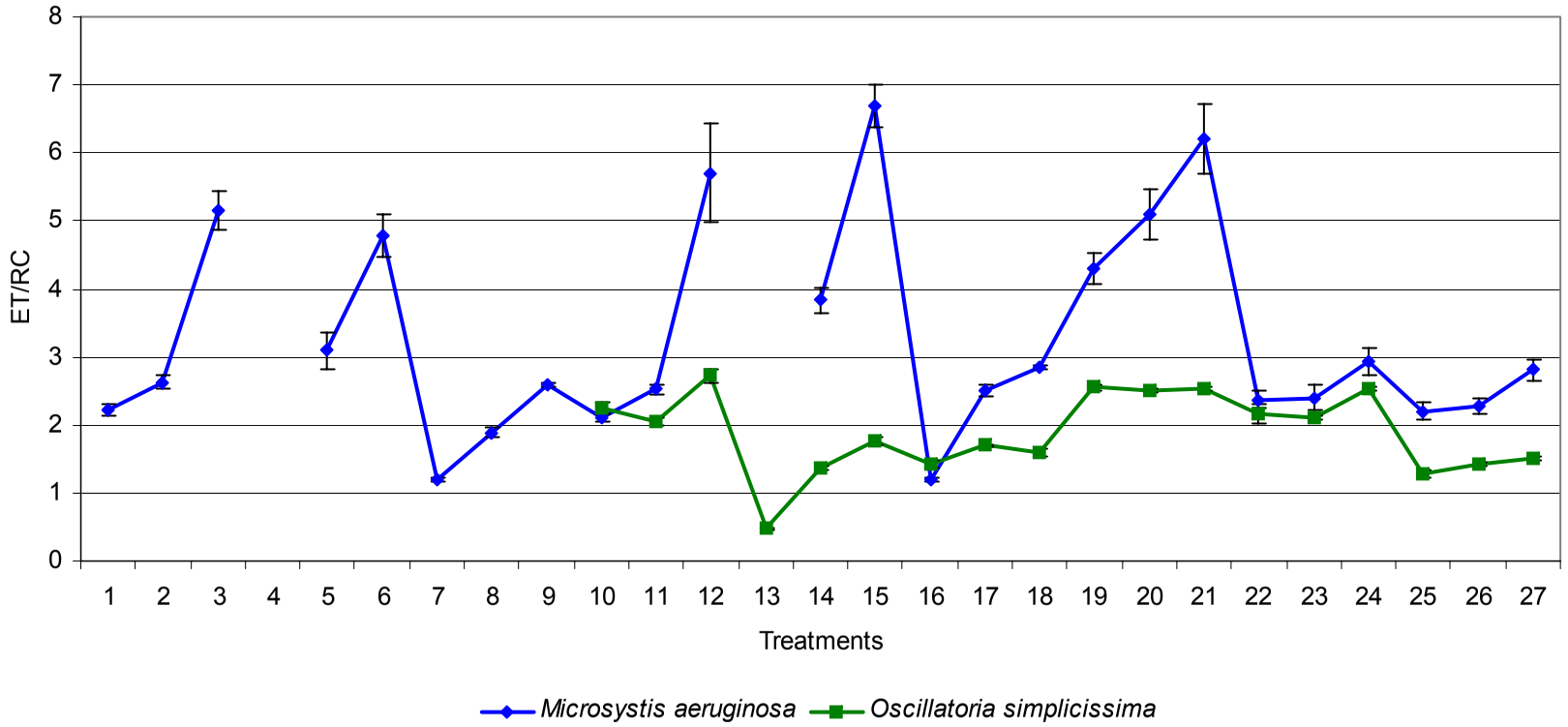


Figure 6.5: Comparison of the ET/RC of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

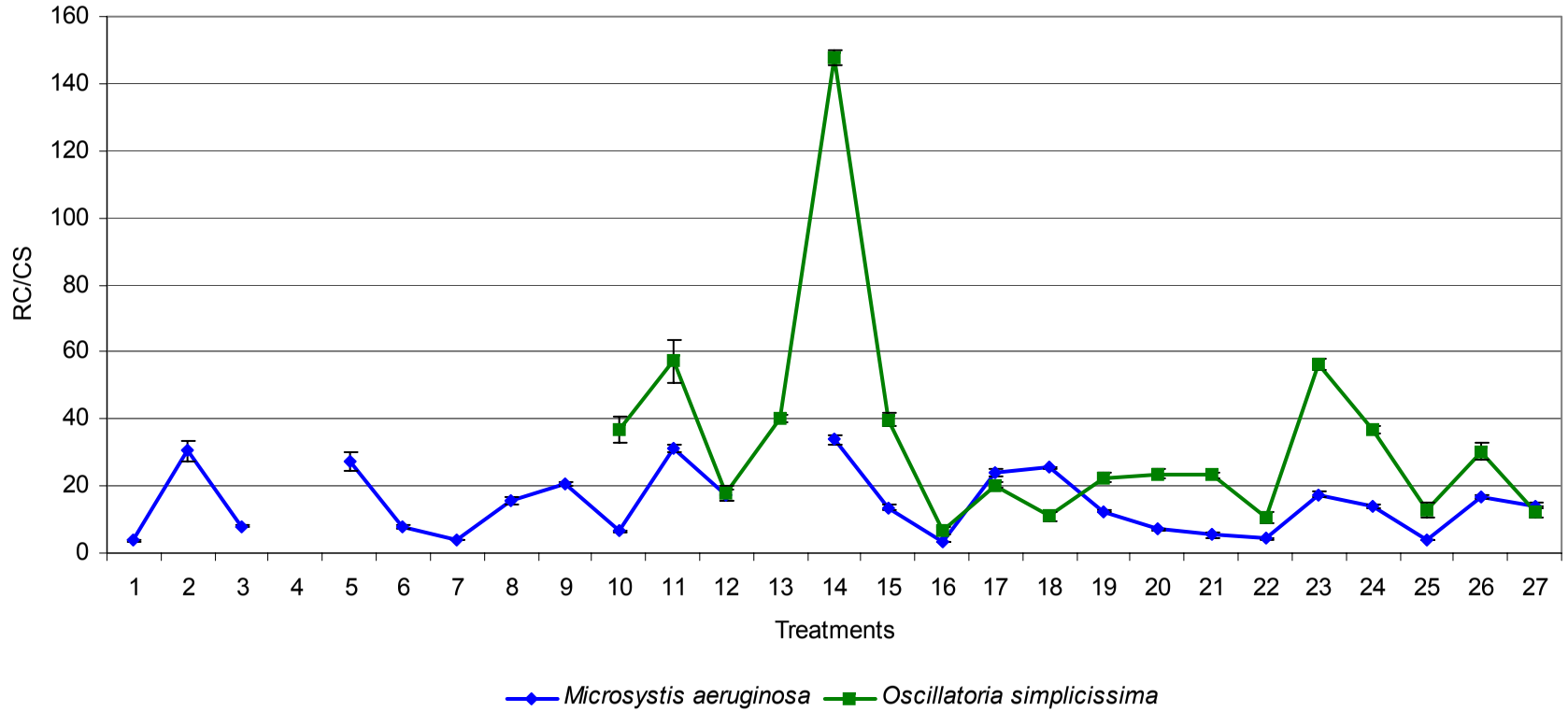


Figure 6.6: Comparison of the RC/CS of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

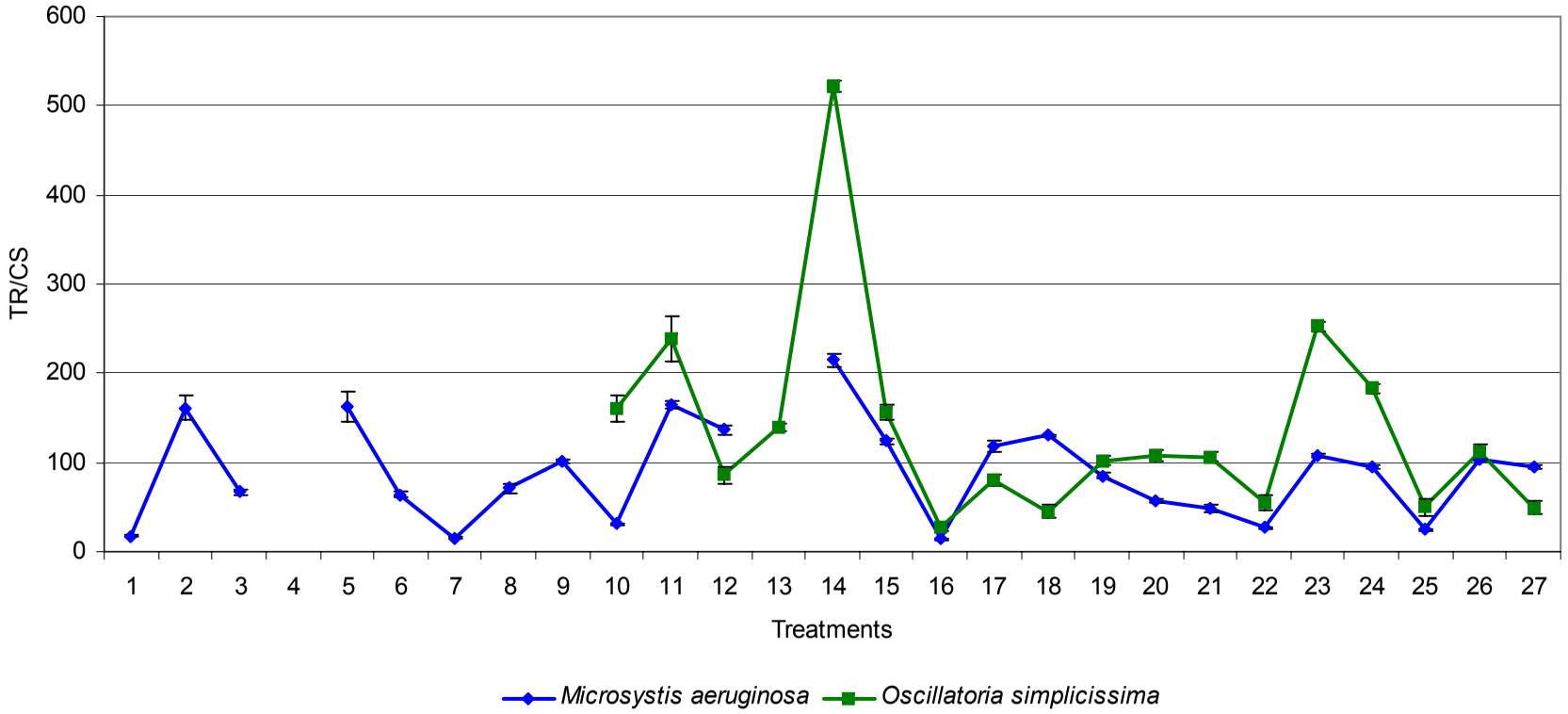


Figure 6.7: Comparison of the TR/CS of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

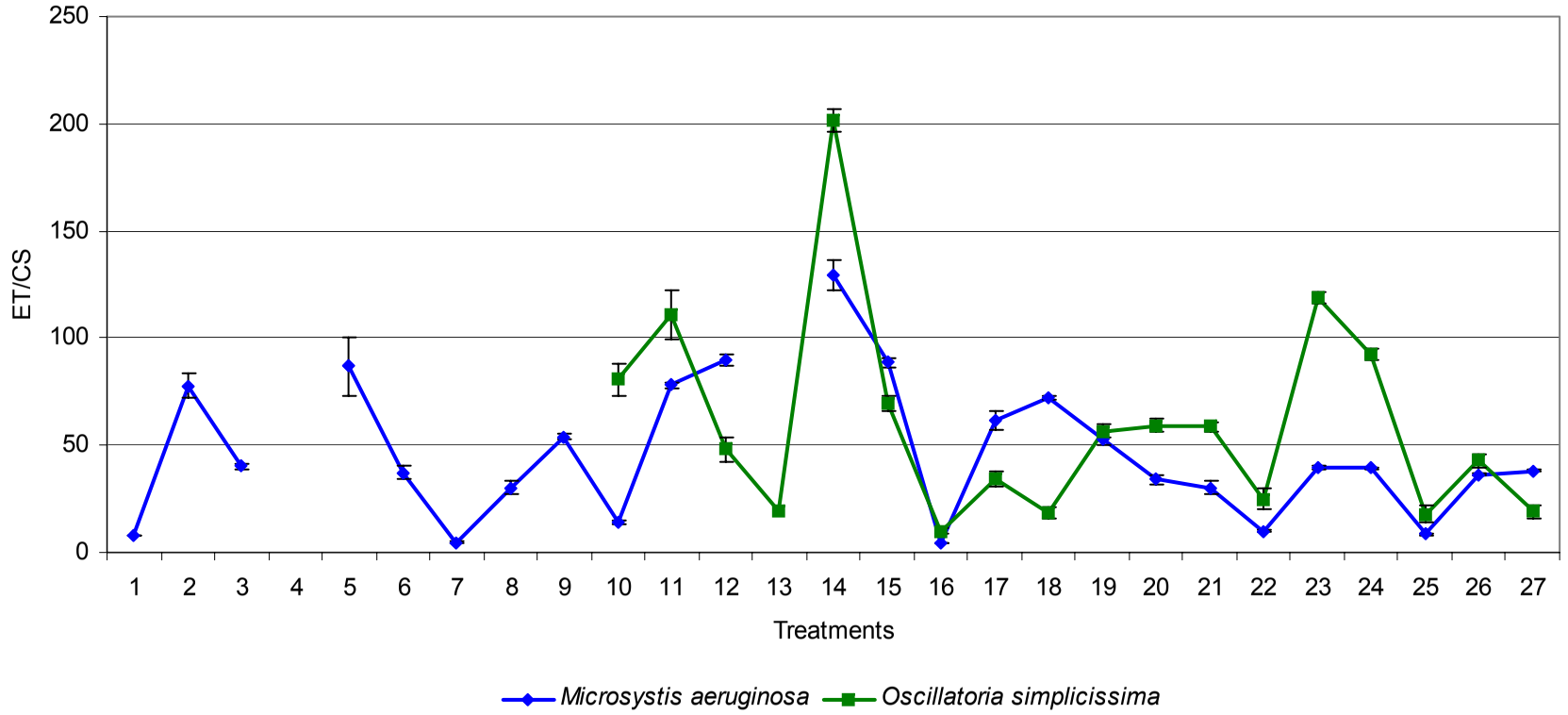


Figure 6.8: Comparison of the ET/CS of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

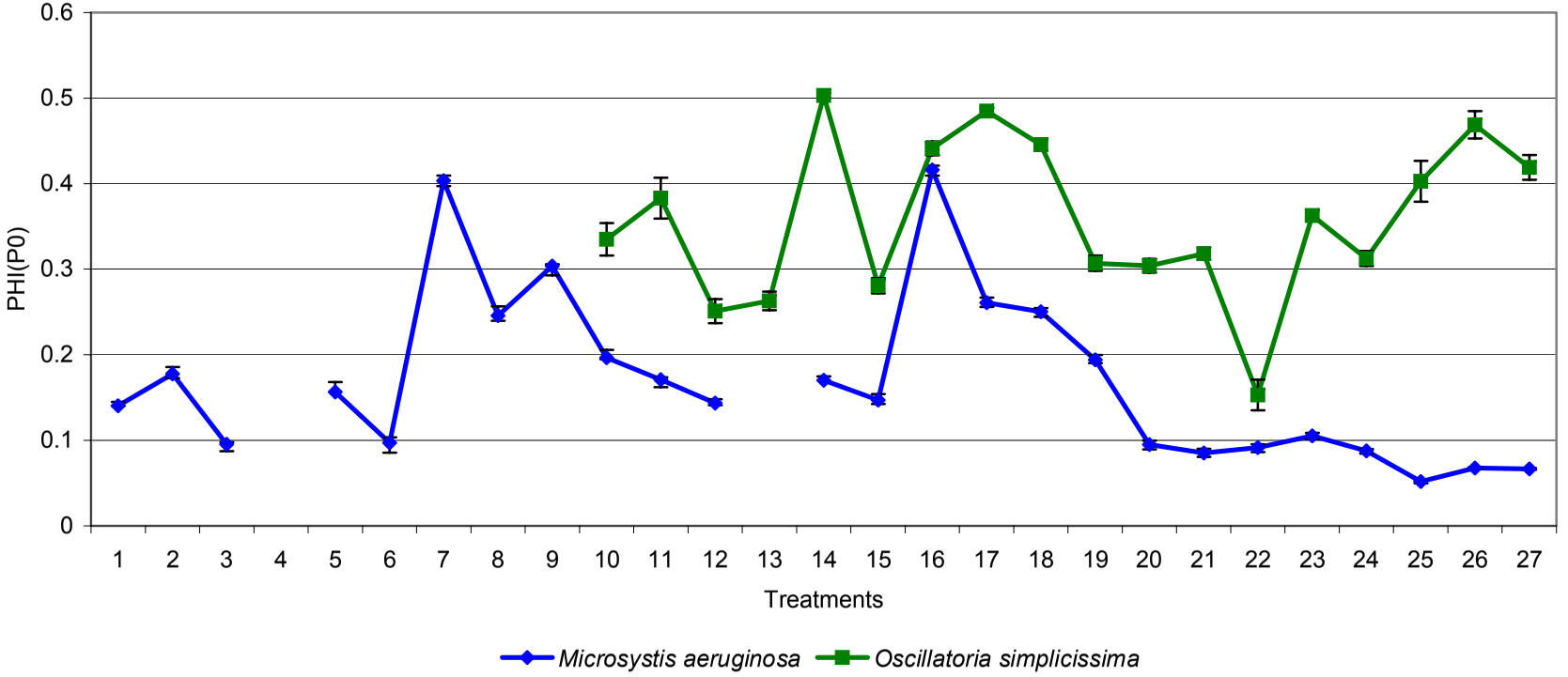


Figure 6.9: Comparison of φ_{PO} of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

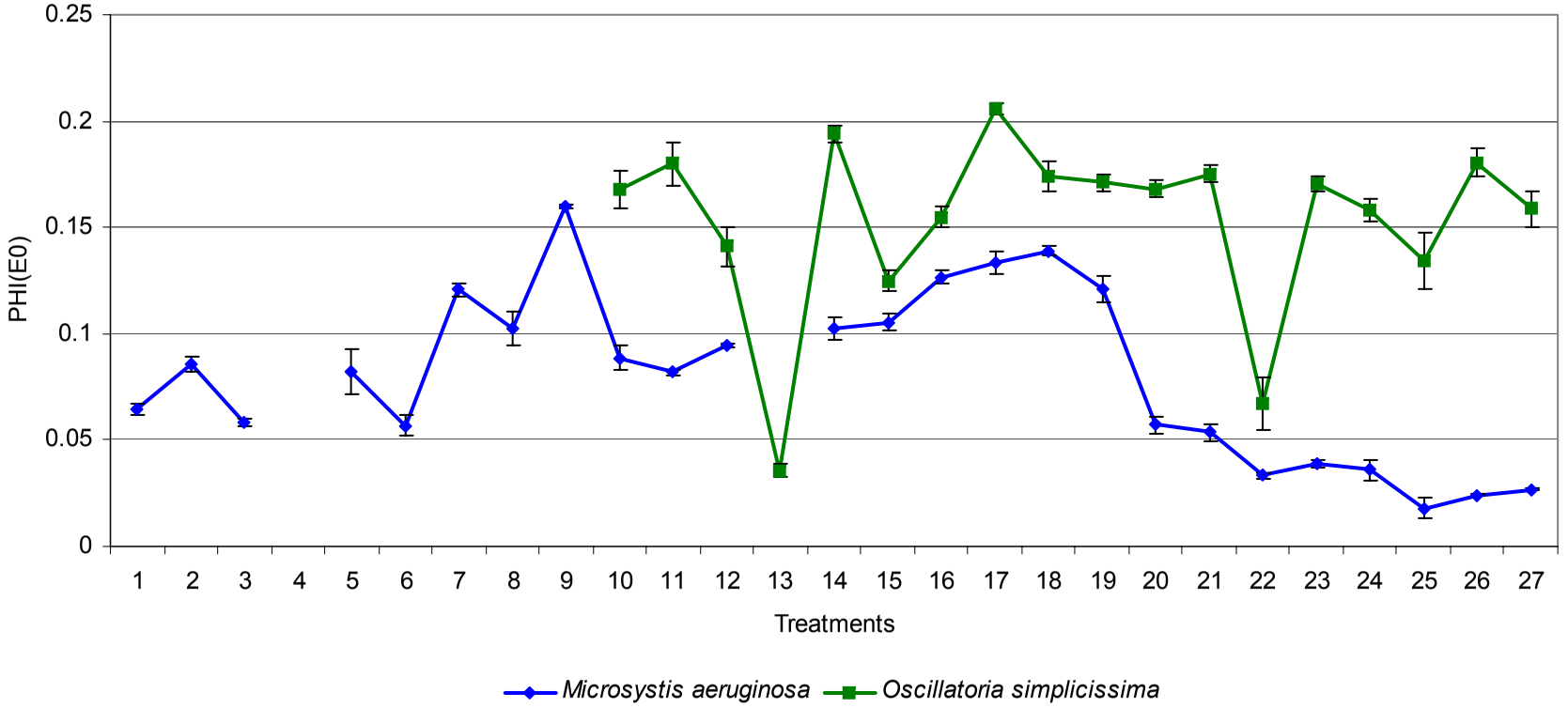


Figure 6.10: Comparison of φ_{EO} of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

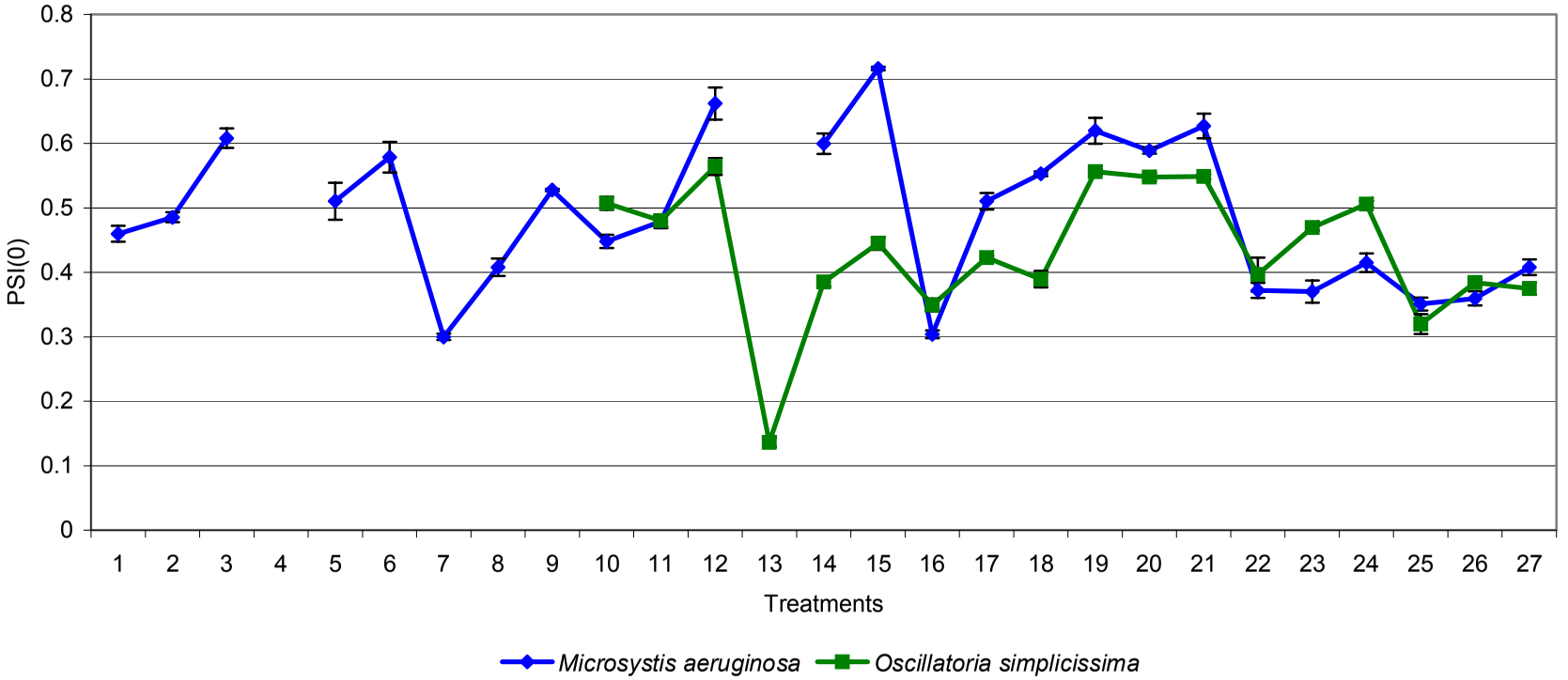


Figure 6.11: Comparison of Ψ_0 of the different treatments of *Microcystis aeruginosa* and *Oscillatoria simplicissima.* Treatments numbers represent the following culturing conditions: 1) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 2) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 3) Temp 18°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 4) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1 5) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 6) Temp 18°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 7) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 8) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 9) Temp 18°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 10) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 11) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 12) Temp 25°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 13) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 14) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 15) Temp 25°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1, 16) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1, 17) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 18) Temp 25°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 19) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 20) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 21) Temp 32°C, 5µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 22) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 23) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 16:1; 24) Temp 32°C, 15µmol.m^{-2}.s$^{-1,}$ N:P 160:1; 25) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 1:1; 26) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 16:1, 27) Temp 32°C, 20µmol.m^{-2}.s$^{-1,}$ N:P 160:1

CHAPTER 7

RE-IDENTIFICATION OF OSCILLATORIA SIMPLICISSIMA ISOLATED FROM THE VAAL RIVER, SOUTH AFRICA, AS PLANKTOTHRIX PSEUDAGARDHII

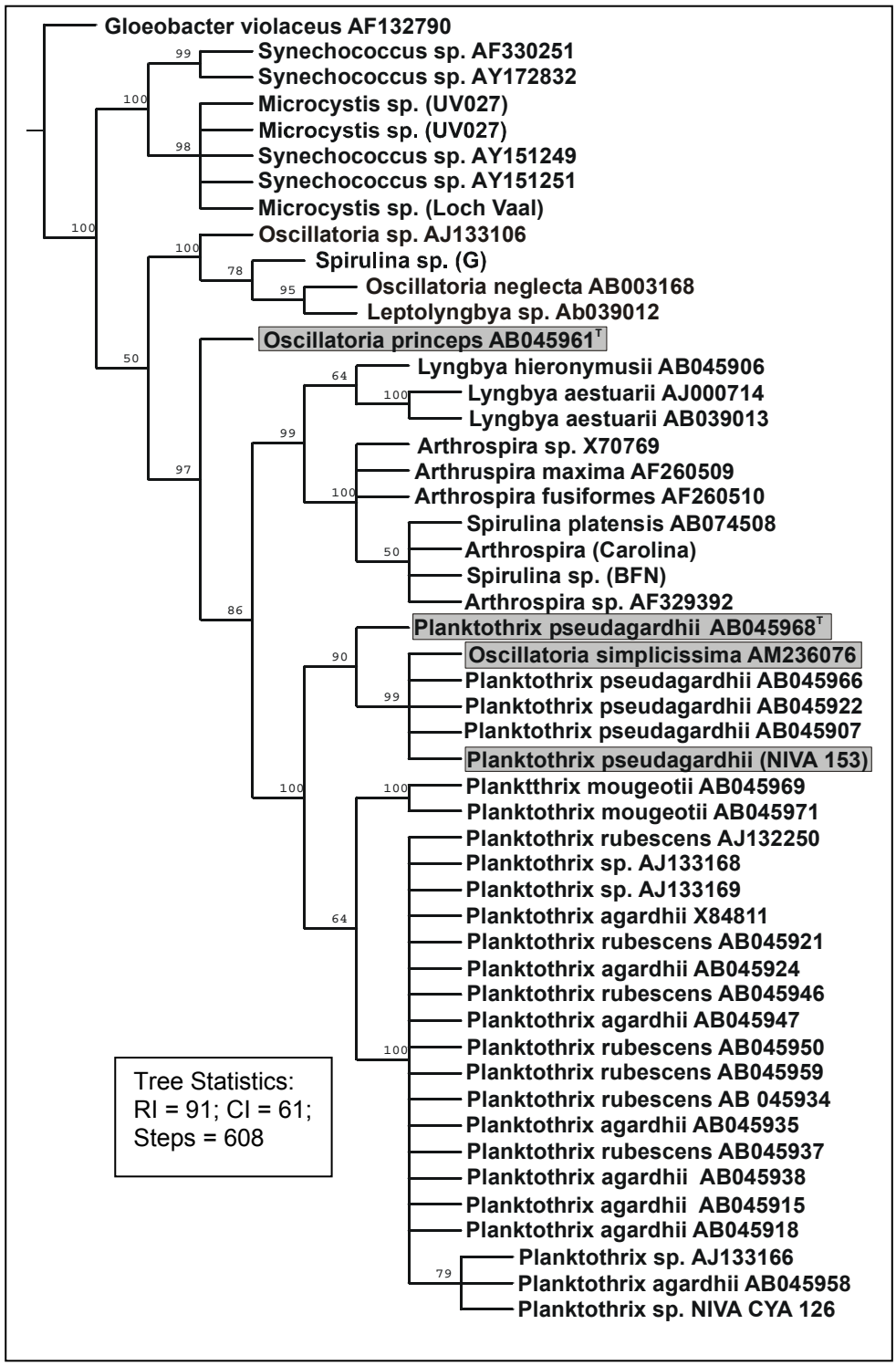


Figure 7.1: Cladogram based on partial 16S rRNA gene sequences. *Gloeobacter violaceus* (PCC 7421) sequence was used as an outgroup. Bootstrap values are indicated at the nodes. Abbreviations: Table 7.1

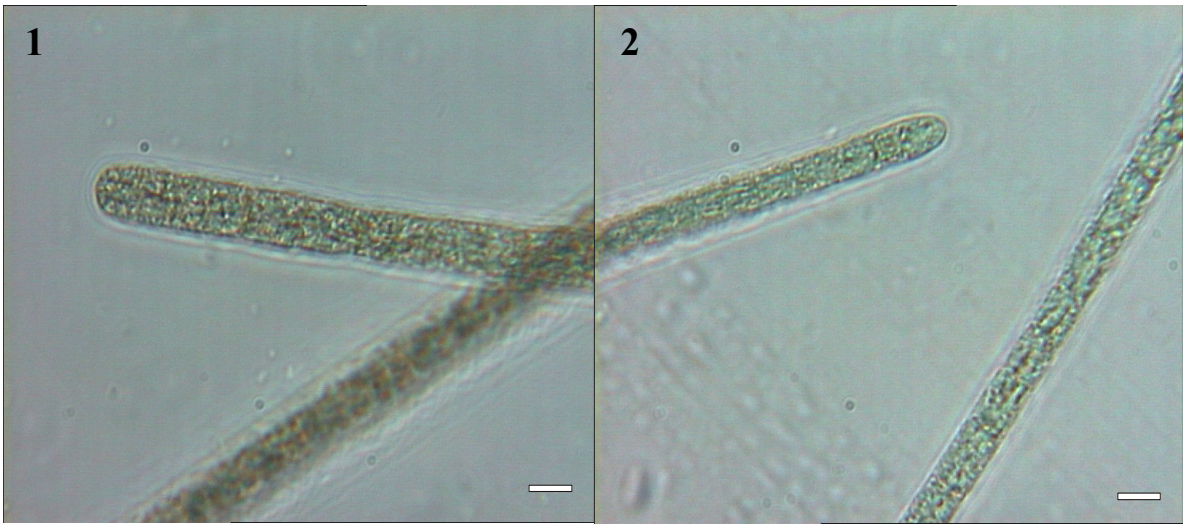


Figure 7.2: Light micrograph of 1) "*O. simplicissima"* and 2) *P. pseudagardhii*, grown at 25°C with a light intensity of 20µmol.m-2s-1. Scalebar = 10µm.

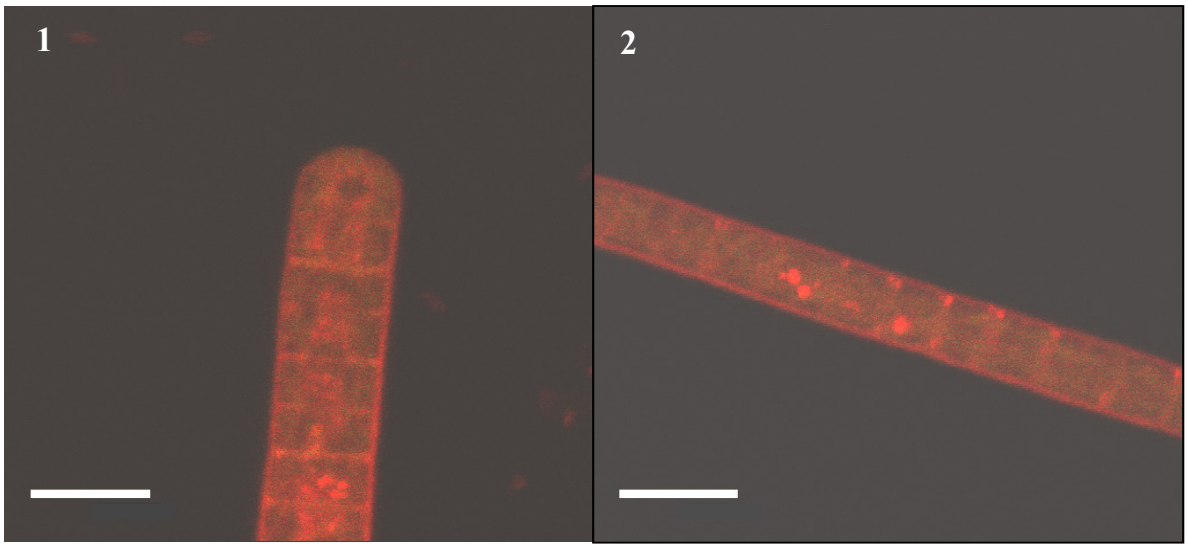


Figure 7.3: Confocal Micrograph of 1) *"O. simplicissma"* and 2) *P. pseudagardhii* grown at 25°C with a light intensity of 20µmol.$m^{-2}s^{-1}$. Scalebar = 5µm.

CHAPTER 8

CONCULSIONS

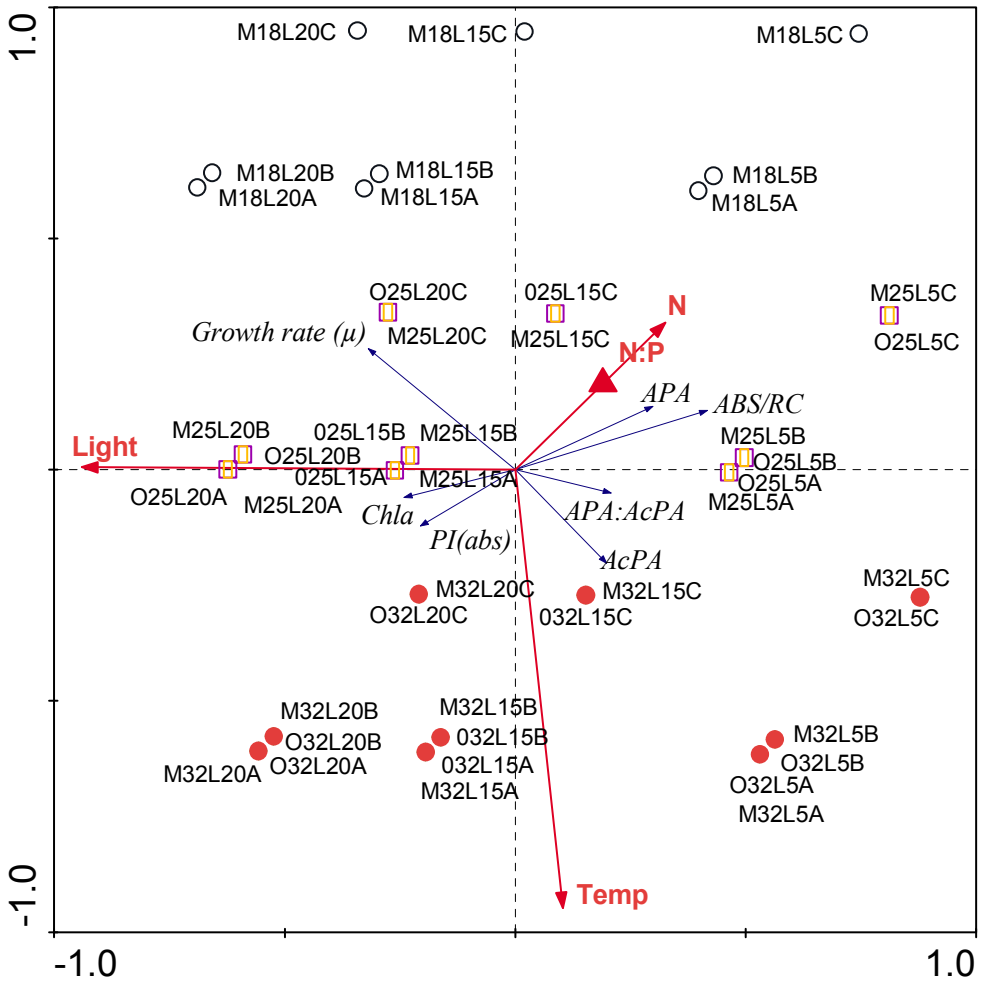


Figure 8.1: RDA ordination biplot showing the three environmental variables (light, temperature and N:P ratio) and physiological parameters (growth rate, chlorophyll a, APA and AcPA, and PI) measured for *M. aeruginosa* and *O. simplicissima*. Abreviations used: M- *M. aeruginosa*. O- *O. simplicissima;* L- light intensity, A- nitrogen limited, B- no limitation and C- phosphate limited

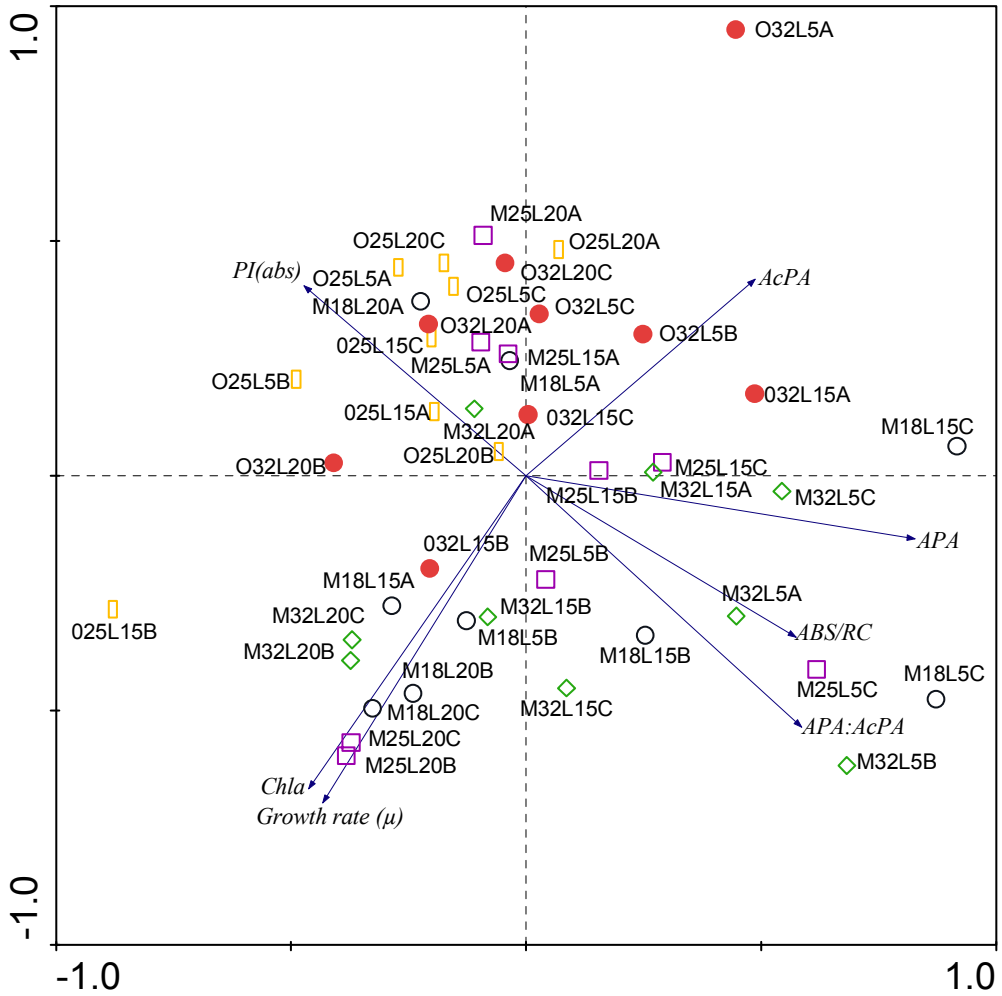


Figure 8.2: PCA ordination biplot showing the different treatment regimes and physiological parameters (growth rate, chlorophyll a, APA and AcPA, and PI) measured for *M. aeruginosa* and *O. simplicissima*. Abreviations used: M- *M. aeruginosa*. O- *O. simplicissima;* L- light intensity, A- nitrogen limited, B- no limitation and C- phosphate limited