Association between the ratio of organic to inorganic nitrogen and the growth of invasive ichthyotoxic golden alga

Rakib Rashel – Biological Sciences, Texas Tech University
Lindsay D. Williams – Natural Resources Management, Texas Tech University
Reynaldo Patiño – U.S. Geological Survey and Texas Tech University

Golden alga (*Prymnesium parvum*)

phys.org

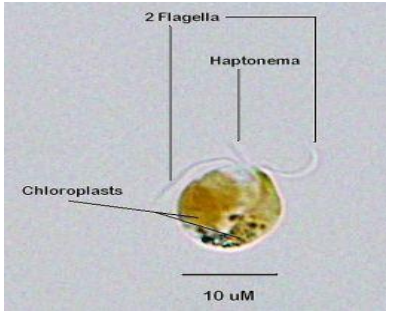
Fish kill at Lake Granbury, TX

TPWD

P. parvum – background and global distribution

- Golden alga (*Prymnesium parvum*) is an invasive, harmful bloom-producing microalga
- First toxic bloom reported in 1920, in The Netherlands
- In the United States, first identified in 1985 in Pecos River, Texas, during a fish-kill event
- Golden alga can produce toxins that are lethal to gilled aquatic animals
- Believed to have originated from coastal and estuarine environments, and to be a relatively recent invader of brackish inland waters
- Found in all continents except Antarctica

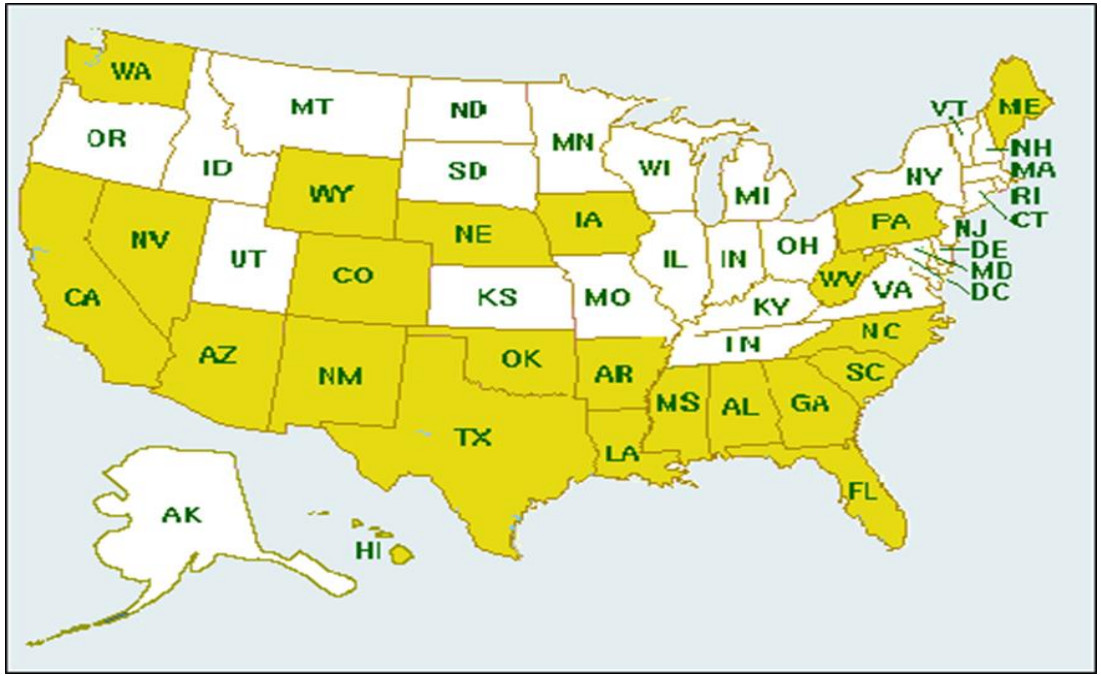
Manning and La Claire, 2010



Picture credit, Greg Southard, TPWD

P. parvum – background and distribution by state

- Toxic blooms of golden alga in USA have caused major ecological damage, and to date have been reported in at least 23 states.
- In Texas, golden alga blooms have continued to spread and today are a common occurrence in five river basins in west and central Texas
- Tens of millions of fish dead and dollars lost solely in Texas



Israël (2013)

P. parvum – environmental regulations

- The environmental regulation of golden alga growth has been the subject of intense research but important questions remain unanswered.
  - ✓ For example, the relationship between nutrient stoichiometry – especially of organic and inorganic fractions – and golden alga growth is not well understood
- Golden alga can utilize organic N (N_O) and inorganic N (N_I) as source of nitrogen to meet its nutrition requirements
- Field studies by our laboratory reported that golden alga abundance is positively associated with N_O and negatively with N_I (Pecos River, TX and NM), and that abundance also declines seasonally as N_I increases (upper Colorado River, TX)
- Laboratory studies have shown that N_I can have a negative influence on golden alga growth at high concentrations, but experimental data regarding the influence of N_O or of changes in relative concentrations of both fractions is insufficient

Research Objective

To experimentally characterize the influence of different ratios of organic (urea or glycine) to inorganic Nitrogen (sodium nitrate) on golden alga growth

Experimental Design and Analysis

Culture medium:

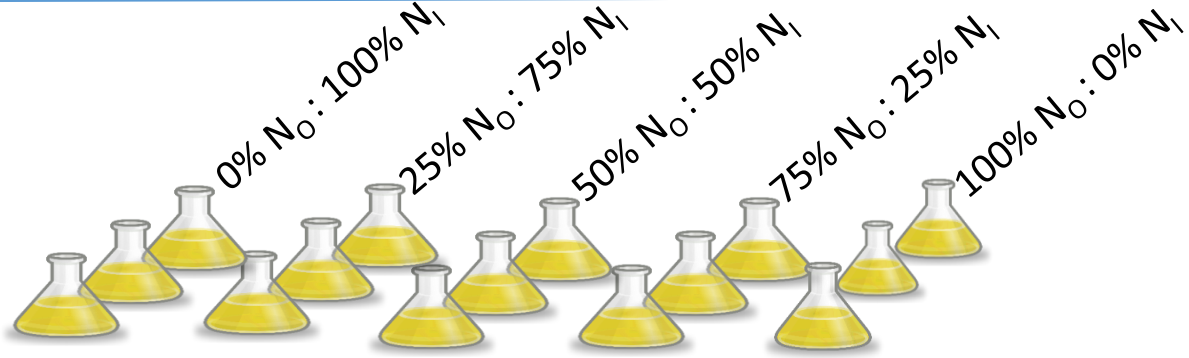
Artificial Sea Water (UTEX culture medium) diluted to salinity of 5 and enriched with f/2 levels of nutrients

Nitrogen treatments:

- Five molar ratios of N_I : N_O at the beginning of the cultures
  100:0%, 75:25%, 50:50%, 25:75% and 0:100%.
  Total N concentration was constant at 880 μM.
- Source of N_I: sodium nitrate
- Source of N_O: urea or glycine

- **All other culture conditions were kept constant**

Experimental Design and Analysis



- Initial cell density: 100 cells/ml
- Volume: 100 ml
- Photoperiod: 12L: 12D
- Irradiance: ~6500 lux
- Temperature: 22 °C
- Inc. period: 27 days
- Cell counts every 3 days

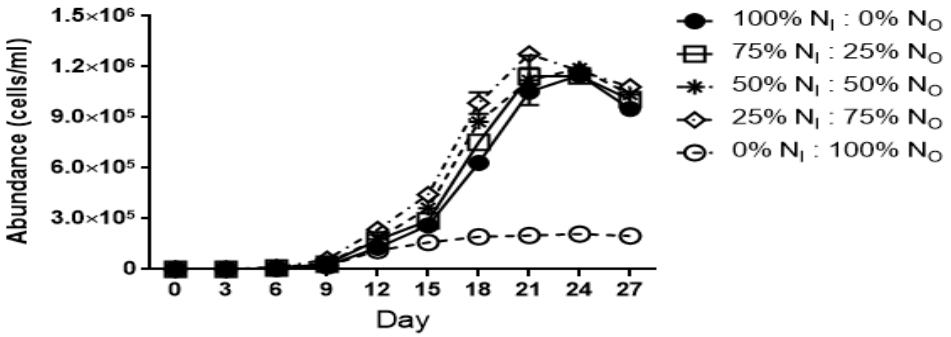
Dependent variables measured

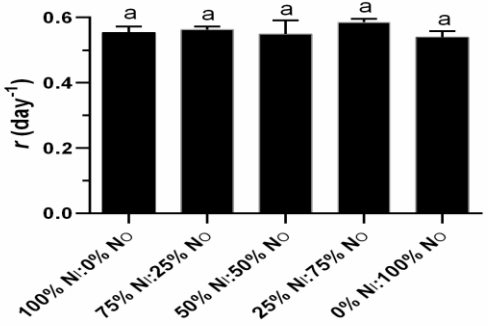
- Exponential growth rate (*r* – growth rate during exponential phase) was calculated by following equation: $\boldsymbol{r = (\ln N_2 - \ln N_1)/(t_2 - t_1)}$, where N_1 and N_2 = density at time t_1 and t_2.
- Maximum cell density (highest cell count)

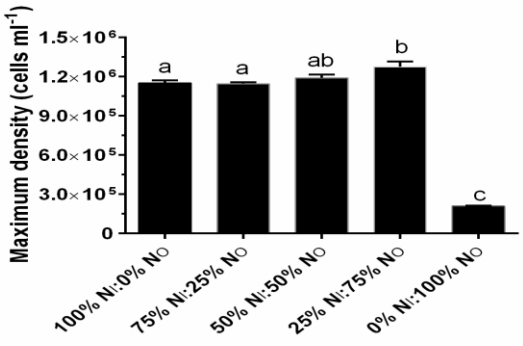
Statistical analysis

- Differences among treatment levels were analyzed using 1-way ANOVA followed by Tukey's HDS

Results – Urea



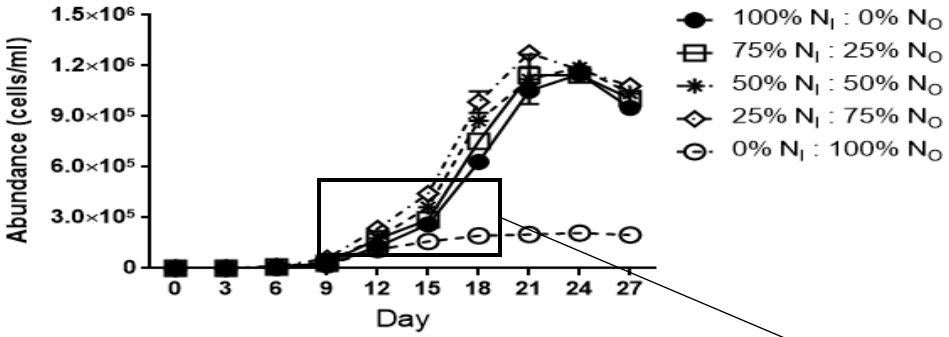




Highlights

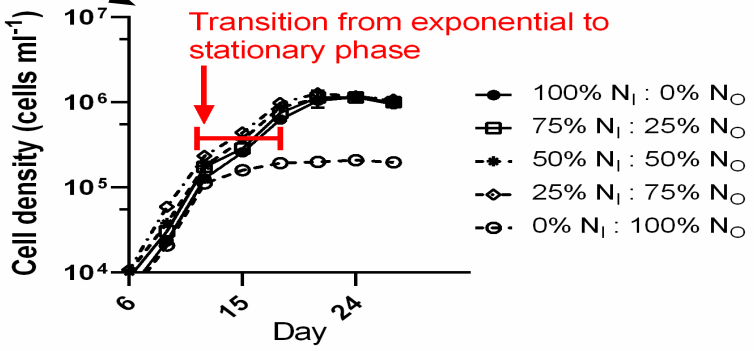
- Exponential growth rate was not affected by changes in initial N_I:N_O ratio
- Maximum cell density seemed to increase gradually with increasing relative concentration of N_O and reached highest levels at 75% N_O, followed by a sharp decline when only N_O was present

Results – Urea

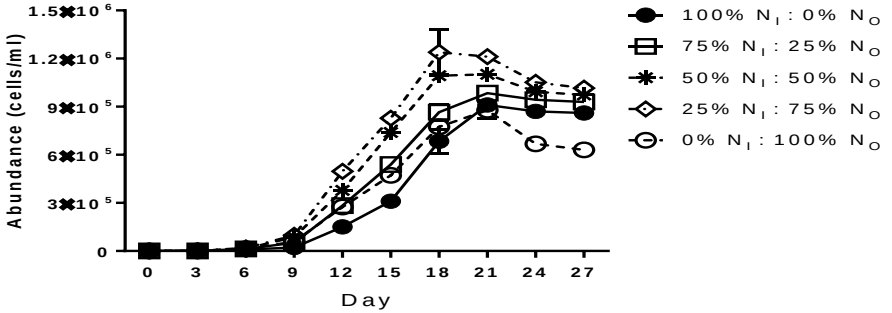


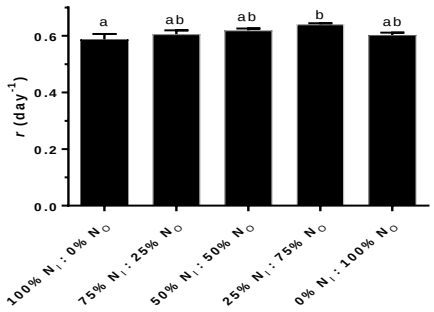
Highlights

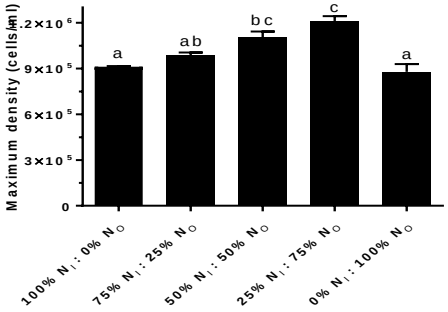
- The decline in maximum cell density when N_O is the sole source of N was due to reduced growth during the transition period from exponential to stationary phases



Results – Glycine







Highlights

- Exponential growth rate seemed to increase slightly at 75% N_O
- Maximum cell density increased gradually with increasing relative concentration of N_O and reached highest levels at 75% N_O, followed by a moderate decline when only N_O was present

Conclusions

- Golden alga can grow in the exclusive presence of N_O or N_I but optimal growth occurs when both are present and N_O is predominant
  - ✓ Specifically, maximum cell density increased as the fraction of N_O increased from 0 to 75%, and decreased when only N_O was present
- Compared to Urea, Glycine seemed to be the preferred source of N_O
- Exponential growth rate was not affected when only Urea was present, but growth rate during transition from exponential to stationary phase was severely reduced, consequently leading to greatly reduced maximum cell density

Conclusions

Ecological implications

- The present findings are consistent with and confirm field observations indicating that N_O is positively associated with golden alga abundance
- This information provides additional context for understanding the association between nutrient stoichiometry and golden alga growth in the field
- This information also may be useful to inform mitigation and controls strategies to curb the incidence and prevent the further spread of golden alga blooms

Acknowledgements

- Dr. Reynaldo Patiño lab

- TX Coop Unit Cooperators

- Association of Biologists at Texas Tech University (TTUAB) for their research grant to support this study


Questions?