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Effect of NaCl on the formation of hormogones in *Oscillatoria limosa*

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Abstract

NaCl at 0.05 or 0.1 mol/L concentrations increased the percentage of hormogones formation in *Oscillatoria limosa* and this seems to be because of necridia formation in the algal filaments. The maximum number of hormogones (which was more than 50% of total algal filaments) was formed at 0.3 mol/L NaCl on 3 day of inoculation. All filaments and hormogones of the alga died rapidly on 5 and 4 day of inoculation at 0.4 and 0.5 mol/L of NaCl, respectively**.**

Key words: Hormogonia**,** *Oscillatoria limosa*, NaCl.

Introduction

Many filamentous blue-green algae reproduced vegetatively by the formation of hormogones. Although, sodium is an important requirement for the growth of blue-green algae (Thomas e*t al.*, 1987), it inhibited or suppressed the growth of *Anabaena* sp. at concentration more than 5 mM (Sinha and Häder, 1996). Percentage survival of *Lyngbya major*, *L. birgei*, *Aphanothece pallida*, *Gloeocapsa atrata*, *Oscillatoria subbrevis*, *O. animalis* and *Myxosarcina burmensis* decreased in media containing 0.2–0.5 mol/L NaCl (Gupta and Agrawal, 2008). *Anabaena* sp. synthesized osmoprotective compounds and accumulates sucrose as a salt-adaptation strategy (Salerno *et al*., 2004). *Aphanothece halophytica* had optimal growth at 0.5 M NaCl (Surasak *et al*., 2010). *Spirulina platensis* had a decrease in dry weight and chlorophyll a content at 0.04 and 0.08M NaCl (Shalaby *et al*., 2010).

The present study, reports the vegetative survivability and hormogones formation in *Oscillatoria limosa* under different concentrations of NaCl.

Material and Methods

Algal material*:* Bluish-green mat of *O. limosa* was collected from a ditch at the garden of Botany Department, University of Allahabad. The unialgal cultures of the alga were isolated and grown in BG 11 medium (Stanier *et al* 1971; pH adjust to 7.5 prior to autoclaving) at the temperature 25 ± 1°C and fluorescent light intensity of *ca.* 40 µmol m^{-2} s^{-1} for 16 h per day in the culture chamber. The algal material was identified with the help of Desikachary (1959).

Almost all long filaments of the alga (mostly of more than 40 cells length), surviving cent per cent, isolated from 7-day-old cultures (short fragments of the alga remained suspended in the culture medium) were used as inoculants to start all experiments in the present study. Salt stress was provided to the algal material by inoculating it into liquid BG 11 medium containing 0.1-1.0 mol/L NaCl. All of the inoculated culture tubes were placed in the culture chamber at control culture conditions. Each set of experiment has three replicates so as to calculate standard error (SE) (using Statistica 8.0 software). Cultures were examined periodically to determine the percentage vegetative survival of the alga (by observing the live versus dead filaments of the alga out of total filaments 2000- 2500 counted) and the percentage of hormogonia (by counting the number of the hormogonia which were mostly of 1 - 40 cells long) out of total filaments observed (live or dead).

Results and Discussion

All filaments of *O. limosa* died on 52, 46, 34, 17, 8, 5, and 4 day after inoculation at 0.0(control), 0.1 0.15, 0.2, 0.3, 0.4 and 0.5 mol/L NaCl, respectively; thus there was a negative correlation between NaCl concentration and survivability of the alga. Agrawal and Singh (2002) reported an adverse effect of NaCl on the vegetative survivability of

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Lyngbya martensiana, Oscillatoria agardhii, Nostoc calcicola, Hormidium fluitans, Spirogyra sp. and Vaucheria geminata at all concentrations of NaCl used (0.1 to 0.8 M). *Synechococcus* sp. PCC 7942 showed an inactivation of photosystem I and II at 0.05M NaCl (Allakhverdiev *et al*., 2000).

In the present study, NaCl at 0.1- 0.3 mol/L decreased the vegetative survival of the alga, but it increased the hormogonium formation in the alga (Table 1) and this may be because of necridia formation in the algal filaments. The percentage hormogonia formation was maximum at 0.3 mol/L NaCl on 3 day of inoculation (Table 1).

The exact environmental conditions triggering hormogonia production in blue-green algae remains unknown (Kruskopf *et al.*, 2006). There is no single unique environmental factor inducing hormogonia formation in blue-green algae (Campbell *et al.*, 2007). An abrupt environmental change or a change in the nutritional status of the culture medium induced the hormogonia formation in blue-green algae (Meeks and Campbell 1989). *Calothrix parietina* D184 cultures starved of phosphorous formed hormogonia (Wood *et al.*, 1986). Positive or negative environmental changes can induced the differentiation of hormogonia in an alga, allowing hormogonia (because of their motility) to exploit a more favourable microhabitat, or to escape them an inhospitable microhabitat (Campbell and Meeks 2008). NaCl at 0.4 and 0.5 mol/L kill most of the hormogones and filaments of the present alga rapid (Table 1).

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Table 1. Percentage of live long filaments (F), live hormogones (H), and dead filaments or hormogones (D) of *O. limosa* at different concentrations of NaCl*

Days of inoculation ↓	F, H, D %	Concentration of NaCl (mol/L) →							
		0 (control)	**0.05**	**0.1**	**0.15**	**0.2**	**0.3**	**0.4**	**0.5**
2	**F**	**98.32** ±0.39	**97.75** ±0.92	**93.87** ±0.50	**87.34** ±0.39	**73.26** ±0.61	**40.56** ±0.87	**32.74** ±1.14	**10.57** ±0.46
	H	**01.18** ±0.70	**01.44** ± 0.28	**05.05** ± 0.49	**09.77** ± 0.24	**21.12** ± 0.49	**47.81** ± 0.51	**36.73**±2.07	**29.79**±0.67
	D	**00.50** ±0.58	**00.81** ± 0.04	**01.08** ±0.71	**02.89** ±0.42	**05.62** ±0.79	**11.63** ±0.21	**30.53**±0.37	**59.64**±0.67
3	**F**	**97.04** ±0.42	**94.13** ±1.57	**88.34** ±0.32	**75.35** ±0.82	**44.64** ±0.54	**10.32** ±0.56	**08.54**±0.42	**00.00**
	H	**02.09** ±0.34	**05.89** ±0.30	**09.13** ±0.45	**19.92** ±0.32	**43.74** ±0.46	**63.05** ±0.78	**24.93**±0.29	**06.58**±0.08
	D	**00.87** ±0.63	**00.90** ±0.04	**02.53** ±0.69	**04.73** ±0.92	**11.62** ±0.87	**26.63** ±0.12	**66.53**±0.97	**93.42**±1.23
5	**F**	**92.49** ±0.69	**80.60** ±0.79	**74.37** ±1.33	**51.73** ±0.68	**13.53** ±0.34	**00.00**	**00.00**	-
	H	**04.65** ±0.70	**16.67** ±0.14	**19.01** ±0.49	**33.65** ±0.24	**45.75** ±0.49	**41.27** ±0.94	**00.00**	-
	D	**02.86** ±0.51	**02.73** ±0.05	**06.62** ±0.68	**14.62** ±0.33	**40.72** ±1.19	**58.73** ±0.55	**100**	-
10	**F**	**87.19** ±0.93	**68.78** ±0.97	**61.65** ±0.89	**12.83** ±0.48	**00.00**	**00.00**	-	-
	H	**06.94** ±0.56	**24.76** ±0.58	**26.82** ±1.04	**46.76** ±0.59	**27.37** ±0.40	**00.00**	-	-
	D	**05.87** ±0.12	**06.46** ±0.21	**11.53** ±0.28	**40.41** ±0.58	**72.63** ±0.63	**100**	-	-
20	**F**	**65.54** ±2.53	**50.65** ±0.75	**35.64** ±0.48	**00.00**	**00.00**	-	-	-
	H	**11.51** ±0.28	**30.65** ±0.65	**41.83** ±0.59	**48.89** ±1.48	**00.00**	-	-	-
	D	**21.95** ±0.39	**18.70** ±0.36	**22.53** ±0.38	**51.11** ±0.34	**100**	-	-	-
30	**F**	**35.80±0.65**	**29.79±0.43**	**20.97±0.21**	**00.00**	-			
	H	**16.45±0.43**	**27.67±0.72**	**31.56±0.33**	**46.01±0.72**	-			
	D	**44.75±0.12**	**42.54±0.91**	**47.47±0.39**	**53.99±0.54**	-			

*long filaments were more than 40 cells length; hormogones were mostly of 1-40 cells length; while dead filaments or hormogones had all cells hyaline and somewhat shrink.