

## Nitrogen fixation and growth rates of *Trichodesmium* IMS-101 as a function of light intensity

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**Appendix 1.** Particulate organic carbon (POC) concentrations in  $\mu\text{mol l}^{-1}$  of *Trichodesmium* IMS-101 grown at different photon irradiances. Photosynthetically active radiation (PAR) is indicated in  $\mu\text{mol quanta m}^{-2}\text{s}^{-1}$  as the mid-day peak light intensity during a natural solar cycle. Data for photon irradiances 75 and 1350  $\mu\text{mol quanta m}^{-2}\text{s}^{-1}$  were converted from the light:dark (L:D) cycle experiment as described in the text. Bold numbers are mean values and non-bold numbers are standard deviations (SD)

Day	PAR								
	15	50	75 = L:D 50	180	300	600	900	1100	1350 = L:D 900
0	<b>14.7</b> 3.4	<b>30.4</b> 14.5	<b>47.9</b> 2.3	<b>13.0</b> 3.0	<b>15.7</b> 3.3	<b>20.2</b> 8.1	<b>23.5</b> 9.7	<b>16.1</b> 15.1	<b>47.1</b> 3.4
2	<b>14.4</b> 3.0	<b>21.2</b> 9.6	<b>46.3</b> 1.9	<b>52.2</b> 7.9	<b>66.4</b> 23.0	<b>51.4</b> 3.6	<b>63.2</b> 17.4	<b>51.0</b> 9.5	<b>77.5</b> 3.0
4	<b>40.0</b> 8.4	<b>27.5</b> 8.4	<b>55.9</b> 1.6	<b>78.7</b> 9.6	<b>98.3</b> 6.7	<b>110.0</b> 3.7	<b>106.8</b> 13.6	<b>95.4</b> 4.4	<b>130.3</b> 15.1
6	<b>51.9</b> 21.4	<b>13.7</b> 5.6	<b>89.0</b> 6.5	<b>127.4</b> 8.3	<b>188.2</b> 3.9	<b>189.5</b> 6.4	<b>175.2</b> 8.6	<b>189.4</b> 2.9	<b>200.6</b> 14.7
8	<b>30.5</b> 14.4	<b>18.0</b> 15.7	<b>80.3</b> 3.3	<b>229.7</b> 24.1	<b>286.0</b> 14.8	<b>333.5</b> 34.6	<b>323.4</b> 17.6	<b>271.4</b> 33.3	<b>255.9</b> 34.5
10	<b>18.0</b> 5.1	<b>29.2</b> 2.4		<b>391.5</b> 22.2	<b>464.4</b> 23.2	<b>515.1</b> 25.2	<b>517.4</b> 45.9	<b>457.3</b> 46.0	
11			<b>91.6</b> 4.1						<b>414.6</b> 16.5
12	<b>50.8</b> 7.9	<b>72.6</b> 7.6		<b>573.4</b> 52.9	<b>652.8</b> 5.3	<b>581.9</b> 137.5	<b>760.1</b> 40.2	<b>604.2</b> 100.7	
13			<b>103.8</b> 11.1						<b>552.4</b> 15.8
14	<b>31.7</b> 14.4	<b>37.6</b> 13.1		<b>681.4</b> 13.6	<b>854.7</b> 42.5	<b>810.5</b> 123.5	<b>977.7</b> 44.4	<b>671.4</b> 46.0	
15			<b>132.0</b> 9.7						<b>665.6</b> 63.4
16	<b>44.8</b> 20.5	<b>68.6</b> 15.2		<b>943.3</b> 34.0	<b>1032.9</b> 136.1	<b>1044.9</b> 3.2	<b>1088.3</b> 87.8	<b>717.9</b> 167.3	
18	<b>16.9</b> 7.9	<b>52.7</b> 6.7		<b>1135.3</b> 39.3	<b>1219.7</b> 129.9	<b>1328.6</b> 36.2	<b>1241.6</b> 127.9	<b>808.6</b> 163.2	
20	<b>55.7</b> 10.3	<b>85.5</b> 5.2		<b>1209.2</b> 88.6	<b>1534.7</b> 119.5	<b>1315.1</b> 100.9	<b>1349.3</b> 118.0	<b>1003.1</b> 100.2	

**Appendix 2.** Particulate organic nitrogen (PON) concentrations in  $\mu\text{mol l}^{-1}$  of *Trichodesmium* IMS-101 grown at different photon irradiances. Photosynthetically active radiation (PAR) is indicated in  $\mu\text{mol quanta m}^{-2}\text{s}^{-1}$  as the mid-day peak light intensity during a natural solar cycle. Data for photon irradiances 75 and 1350  $\mu\text{mol quanta m}^{-2}\text{s}^{-1}$  were converted from the light:dark (L:D) cycle experiment as described in the text. Bold numbers denote mean values and non-bold numbers are SDs

Day	PAR								
	15	50	75 = L:D 50	180	300	600	900	1100	1350 = L:D 900
0	<b>7.1</b> 1.3	<b>10.7</b> 2.0	<b>12.3</b> 0.4	<b>8.1</b> 0.4	<b>7.0</b> 0.4	<b>8.3</b> 1.9	<b>6.6</b> 0.3	<b>7.2</b> 2.0	<b>10.8</b> 0.2
2	<b>6.8</b> 1.6	<b>6.4</b> 2.0	<b>14.6</b> 1.8	<b>10.4</b> 0.6	<b>13.9</b> 1.3	<b>12.5</b> 0.7	<b>13.7</b> 2.6	<b>13.5</b> 1.3	<b>16.6</b> 0.4
4	<b>8.3</b> 0.1	<b>13.7</b> 5.0	<b>17.0</b> 0.7	<b>16.2</b> 0.8	<b>18.4</b> 0.6	<b>22.9</b> 1.1	<b>22.8</b> 3.2	<b>20.0</b> 0.5	<b>27.1</b> 2.6
6	<b>6.5</b> 3.8	<b>4.1</b> 1.8	<b>19.8</b> 0.8	<b>22.2</b> 0.6	<b>33.0</b> 2.4	<b>36.1</b> 0.4	<b>35.9</b> 3.0	<b>37.1</b> 4.3	<b>37.1</b> 2.0
8	<b>10.8</b> 1.9	<b>7.9</b> 1.4	<b>14.5</b> 0.5	<b>44.1</b> 4.8	<b>51.0</b> 3.7	<b>58.3</b> 3.3	<b>59.0</b> 1.0	<b>48.9</b> 5.7	<b>40.7</b> 5.4
10	<b>6.6</b> 0.9	<b>8.9</b> 0.4		<b>65.2</b> 4.1	<b>76.7</b> 4.9	<b>88.8</b> 12.9	<b>87.0</b> 7.9	<b>76.5</b> 4.6	
11			<b>18.7</b> 0.6						<b>71.9</b> 4.3
12	<b>8.5</b> 1.6	<b>11.6</b> 1.2		<b>100.2</b> 9.8	<b>116.3</b> 5.0	<b>109.5</b> 20.4	<b>135.3</b> 5.1	<b>109.9</b> 12.5	
13			<b>21.3</b> 1.7						<b>97.8</b> 1.4
14	<b>8.2</b> 2.0	<b>12.6</b> 1.4		<b>124.0</b> 5.4	<b>149.6</b> 5.3	<b>150.2</b> 22.0	<b>171.8</b> 8.6	<b>125.0</b> 8.0	
15			<b>26.2</b> 2.1						<b>116.3</b> 7.0
16	<b>12.8</b> 4.2	<b>15.9</b> 3.8		<b>174.4</b> 3.9	<b>187.3</b> 22.2	<b>198.0</b> 4.8	<b>198.4</b> 15.7	<b>136.9</b> 25.6	
18	<b>9.4</b> 1.3	<b>12.9</b> 0.6		<b>205.7</b> 14.7	<b>213.3</b> 25.0	<b>232.7</b> 8.3	<b>218.5</b> 21.8	<b>146.4</b> 26.3	
20	<b>7.1</b> 1.9	<b>12.6</b> 1.9		<b>201.2</b> 14.1	<b>243.2</b> 22.8	<b>226.4</b> 10.8	<b>215.3</b> 14.8	<b>161.7</b> 12.5	

**Appendix 3.** Chlorophyll *a* (chl *a*):particulate organic carbon (POC) stoichiometry (weight:weight) of *Trichodesmium* IMS-101 grown at different photon irradiances. Photosynthetically active radiation (PAR) is indicated in  $\mu\text{mol quanta m}^{-2} \text{s}^{-1}$  as the mid-day peak light intensity during a natural solar cycle. The light:dark (L:D) cycle experiment yielded no reliable chl *a* measurements and the respective data were excluded. Bold numbers denote mean values and non-bold numbers are SDs. Mean values for all data are calculated for Days 4 to 18 of each light treatment and are given at the bottom of the table

Day	PAR						
	15	50	180	300	600	900	1100
0	<b>0.020</b> 0.001	<b>0.013</b> 0.005	<b>0.030</b> 0.006	<b>0.023</b> 0.004	<b>0.020</b> 0.009	<b>0.015</b> 0.004	<b>0.021</b> 0.006
2	<b>0.034</b> 0.005	<b>0.019</b> 0.002	<b>0.015</b> 0.002	<b>0.013</b> 0.003	<b>0.013</b> 0.002	<b>0.011</b> 0.003	<b>0.013</b> 0.003
4	<b>0.014</b> 0.002	<b>0.026</b> 0.008	<b>0.020</b> 0.004	<b>0.015</b> 0.002	<b>0.013</b> 0.001	<b>0.013</b> 0.001	<b>0.014</b> 0.001
6		<b>0.058</b> 0.020	<b>0.021</b> 0.001	<b>0.015</b> 0.000	<b>0.015</b> 0.001	<b>0.015</b> 0.000	<b>0.013</b> 0.001
8	<b>0.030</b> 0.008	<b>0.033</b> 0.010	<b>0.018</b> 0.001	<b>0.015</b> 0.001	<b>0.013</b> 0.001	<b>0.013</b> 0.001	<b>0.013</b> 0.001
10	<b>0.033</b> 0.002	<b>0.037</b> 0.004	<b>0.017</b> 0.001	<b>0.015</b> 0.002	<b>0.010</b> 0.003	<b>0.011</b> 0.004	<b>0.013</b> 0.001
11							
12	<b>0.015</b> 0.003	<b>0.016</b> 0.001	<b>0.018</b> 0.000	<b>0.018</b> 0.001	<b>0.012</b> 0.001	<b>0.013</b> 0.001	<b>0.011</b> 0.001
13							
14	<b>0.019</b> 0.004		<b>0.016</b> 0.006	<b>0.016</b> 0.001	<b>0.013</b> 0.000	<b>0.013</b> 0.000	<b>0.012</b> 0.000
15							
16	<b>0.033</b> 0.006	<b>0.017</b> 0.008	<b>0.018</b> 0.001	<b>0.016</b> 0.003	<b>0.012</b> 0.000	<b>0.012</b> 0.000	<b>0.011</b> 0.001
18	<b>0.038</b> 0.007	<b>0.021</b> 0.002	<b>0.014</b> 0.001	<b>0.011</b> 0.002	<b>0.009</b> 0.001	<b>0.011</b> 0.001	<b>0.009</b> 0.001
20	<b>0.018</b> 0.003	<b>0.022</b> 0.003	<b>0.019</b> 0.000	<b>0.014</b> 0.001	<b>0.012</b> 0.001	<b>0.010</b> 0.000	<b>0.010</b> 0.000
<b>Mean</b>	<b>0.025</b>	<b>0.029</b>	<b>0.018</b>	<b>0.015</b>	<b>0.012</b>	<b>0.012</b>	<b>0.012</b>
SD	0.011	0.016	0.013	0.002	0.002	0.002	0.002

**Appendix 4.** POC:PON stoichiometry (mol:mol) of *Trichodesmium* IMS-101 grown at different light intensities. Photosynthetically active radiation (PAR) is indicated in  $\mu\text{mol quanta m}^{-2} \text{s}^{-1}$  as the mid-day peak light intensity during a natural solar cycle. Data for photon irradiances 75 and 1350  $\mu\text{mol quanta m}^{-2} \text{s}^{-1}$  were converted from the light:dark (L:D) cycle experiment as described in the text. Bold numbers denote mean values and non-bold numbers are SDs. Mean values for all data are calculated for Days 4 to 18 (L:D cycle: 4 to 15) for each light treatment and are given at the bottom of the table

Day	PAR								
	15	50	75 = L:D 50	180	300	600	900	1100	1350 = L:D 900
0	<b>2.07</b> 0.11	<b>2.74</b> 0.77	<b>3.90</b> 0.14	<b>1.59</b> 0.34	<b>2.26</b> 0.55	<b>2.39</b> 0.45	<b>2.74</b> 0.29		<b>4.36</b> 0.27
2	<b>2.16</b> 0.49	<b>3.20</b> 0.92	<b>3.21</b> 0.48	<b>4.53</b> 0.34	<b>3.99</b> 0.11	<b>4.13</b> 0.51	<b>4.58</b> 0.41	<b>3.79</b> 0.72	<b>4.66</b> 0.18
4	<b>4.26</b> 0.38	<b>2.93</b> 0.03	<b>3.28</b> 0.19	<b>4.85</b> 0.35	<b>5.33</b> 0.20	<b>4.80</b> 0.22	<b>4.69</b> 0.10	<b>4.77</b> 0.24	<b>4.81</b> 0.10
6		<b>2.87</b> 0.89	<b>4.49</b> 0.23	<b>5.75</b> 0.44	<b>5.72</b> 0.40	<b>5.25</b> 0.12	<b>4.90</b> 0.17	<b>5.15</b> 0.64	<b>5.40</b> 0.12
8	<b>3.33</b> 0.24	<b>3.07</b> 0.64	<b>5.55</b> 0.05	<b>5.21</b> 0.06	<b>5.62</b> 0.24	<b>5.71</b> 0.36	<b>5.48</b> 0.22	<b>5.55</b> 0.13	<b>6.29</b> 0.16
10	<b>2.69</b> 0.52	<b>3.27</b> 0.12		<b>6.01</b> 0.04	<b>6.06</b> 0.39	<b>6.19</b> 0.26	<b>5.95</b> 0.10	<b>5.97</b> 0.38	
11			<b>4.92</b> 0.28						<b>5.77</b> 0.15
12	<b>5.98</b> 0.46	<b>6.23</b> 0.12		<b>5.73</b> 0.03	<b>5.62</b> 0.28	<b>5.28</b> 0.26	<b>5.62</b> 0.18	<b>5.48</b> 0.32	
13			<b>4.88</b> 0.21						<b>5.65</b> 0.12
14	<b>3.70</b> 0.98	<b>2.95</b> 0.81		<b>5.49</b> 0.13	<b>5.71</b> 0.10	<b>5.40</b> 0.15	<b>5.69</b> 0.06	<b>5.37</b> 0.10	
15			<b>5.05</b> 0.07						<b>5.71</b> 0.21
16	<b>3.42</b> 0.51	<b>4.34</b> 0.21		<b>5.41</b> 0.07	<b>5.51</b> 0.08	<b>5.34</b> 0.13	<b>5.48</b> 0.02	<b>5.22</b> 0.24	
18	<b>1.76</b> 0.57	<b>4.10</b> 0.57		<b>5.53</b> 0.21	<b>5.72</b> 0.10	<b>5.71</b> 0.11	<b>5.68</b> 0.02	<b>5.51</b> 0.12	
20	<b>7.92</b> 0.63	<b>6.84</b> 0.76		<b>6.01</b> 0.04	<b>6.32</b> 0.11	<b>5.80</b> 0.18	<b>6.26</b> 0.13	<b>6.20</b> 0.15	
<b>Mean</b>	<b>3.57</b>	<b>3.83</b>	<b>4.69</b>	<b>5.50</b>	<b>5.66</b>	<b>5.43</b>	<b>5.44</b>	<b>5.30</b>	<b>5.61</b>
SD	1.39	1.18	0.47	0.46	0.53	0.60	0.49	0.71	0.47

**Appendix 5.** Chl *a*-specific nitrogen fixation rates of *Trichodesmium* IMS-101 (mol N fixed mol chl  $a^{-1} h^{-1}$ ) grown at different photon irradiances. Photosynthetically active radiation (PAR) is indicated in  $\mu\text{mol quanta m}^{-2} \text{s}^{-1}$  as the mid-day peak light intensity during a natural solar cycle. The light:dark (L:D) cycle experiment yielded no reliable chl *a* measurements and the data were excluded. Bold numbers denote mean values and non-bold numbers are SDs

Day	PAR						
	15	50	180	300	600	900	1100
4	<b>1.85</b> 0.11	<b>1.72</b> 0.70	<b>1.69</b> 0.01	<b>2.60</b> 0.45	<b>3.00</b> 0.31	<b>3.09</b> 0.31	<b>3.31</b> 1.05
6	<b>1.35</b> 0.31	<b>1.02</b> 0.05	<b>0.33</b> 0.04	<b>2.04</b> 0.20	<b>3.38</b> 0.29	<b>4.43</b> 1.44	<b>3.02</b> 1.92
8	<b>1.37</b> 0.27	<b>1.38</b> 0.30	<b>1.39</b> 0.13	<b>2.35</b> 0.45	<b>2.31</b> 0.15	<b>2.85</b> 0.08	<b>4.17</b> 0.62
10	<b>1.62</b> 0.15	<b>1.78</b> 0.33	<b>1.44</b> 0.27	<b>2.42</b> 0.39	<b>3.27</b> 0.12	<b>2.94</b> 0.56	<b>2.58</b> 0.19
11							
12	<b>0.74</b> 0.08	<b>1.17</b> 0.16	<b>1.73</b> 0.09	<b>2.34</b> 0.27	<b>3.70</b> 0.21	<b>2.79</b> 0.20	<b>4.45</b> 0.14
13							
14	<b>1.01</b> 1.12	<b>0.83</b> 0.09	<b>0.87</b> 0.48	<b>1.75</b> 0.08	<b>1.97</b> 0.22	<b>1.75</b> 0.29	<b>2.31</b> 0.61
15							
16	<b>1.31</b> 0.50	<b>0.94</b> 0.09	<b>0.80</b> 0.13	<b>1.96</b> 0.00	<b>2.09</b> 0.46	<b>1.01</b> 0.05	<b>0.81</b> 0.12
18	<b>2.90</b> 0.43	<b>1.72</b> 0.27	<b>0.53</b> 0.05	<b>1.59</b> 0.30	<b>1.84</b> 0.62	<b>0.75</b> 0.33	<b>1.57</b> 0.23
20	<b>2.35</b> 0.10	<b>1.64</b> 0.10	<b>0.61</b> 0.06	<b>1.15</b> 0.14	<b>0.52</b> 0.02	<b>0.64</b> 0.02	<b>0.95</b> 0.16

**Appendix 6.** Carbon-specific nitrogen fixation measurements of *Trichodesmium* IMS-101 (mmol N fixed mol C<sup>-1</sup> h<sup>-1</sup>) grown at different photon irradiances. Photosynthetically active radiation (PAR) is indicated in  $\mu\text{mol quanta m}^{-2}\text{s}^{-1}$  as the mid-day peak light intensity during a natural solar cycle. Data for photon irradiances 75 and 1350  $\mu\text{mol quanta m}^{-2}\text{s}^{-1}$  were converted from the light:dark (L:D) cycle experiment as described in the text. Bold numbers denote mean values and non-bold numbers are SDs

Day	PAR								
	15	50	75 = L:D 50	180	300	600	900	1100	1350 = L:D 900
4	<b>0.75</b> 0.05	<b>0.39</b> 0.27	<b>0.10</b> 0.02	<b>0.40</b> 0.00	<b>0.39</b> 0.02	<b>0.47</b> 0.04	<b>0.46</b> 0.02	<b>0.57</b> 0.19	<b>0.31</b> 0.04
6	<b>0.19</b> 0.12	<b>0.14</b> 0.03	<b>0.11</b> 0.03	<b>0.10</b> 0.06	<b>0.53</b> 0.14	<b>0.58</b> 0.02	<b>0.76</b> 0.11	<b>0.49</b> 0.32	<b>0.20</b> 0.06
8	<b>0.36</b> 0.01	<b>0.59</b> 0.12	<b>0.08</b> 0.00	<b>0.30</b> 0.02	<b>0.34</b> 0.01	<b>0.25</b> 0.02	<b>0.40</b> 0.01	<b>0.53</b> 0.00	<b>0.48</b> 0.34
10	<b>0.19</b> 0.06	<b>0.25</b> 0.07	<b>0.13</b> 0.01	<b>0.28</b> 0.05	<b>0.38</b> 0.08	<b>0.39</b> 0.08	<b>0.45</b> 0.13	<b>0.46</b> 0.03	<b>0.39</b> 0.04
11			<b>0.33</b> 0.03						<b>0.42</b> 0.14
12	<b>0.55</b> 0.24	<b>0.42</b> 0.02		<b>0.42</b> 0.02	<b>0.49</b> 0.03	<b>0.56</b> 0.04	<b>0.48</b> 0.10	<b>0.59</b> 0.01	
13			<b>0.27</b> 0.06						<b>0.29</b> 0.10
14	<b>0.46</b> 0.00	<b>0.38</b> 0.02		<b>0.30</b> 0.04	<b>0.36</b> 0.01	<b>0.27</b> 0.04	<b>0.24</b> 0.04	<b>0.31</b> 0.06	
15			<b>0.23</b> 0.04						<b>0.15</b> 0.03
16	<b>0.17</b> 0.05	<b>0.27</b> 0.04		<b>0.21</b> 0.05	<b>0.26</b> 0.05	<b>0.37</b> 0.02	<b>0.17</b> 0.02	<b>0.12</b> 0.02	
18	<b>0.34</b> 0.02	<b>0.45</b> 0.05		<b>0.10</b> 0.02	<b>0.22</b> 0.01	<b>0.21</b> 0.00	<b>0.10</b> 0.05	<b>0.17</b> 0.02	
20	<b>0.46</b> 0.08	<b>0.61</b> 0.04		<b>0.16</b> 0.02	<b>0.21</b> 0.04	<b>0.09</b> 0.03	<b>0.10</b> 0.02	<b>0.12</b> 0.03	