

Effect of *Spirulina platensis* Liquid extract on Germination and Growth of *Triticum aestivum* and *lupinus termis*

Mayada A. Shehawy^{1*}, Ragaa A. Hamouda², Soad M. Mohy El.Din³ and Mervat H. Hussein⁴

² Geenetic Engineering and Biotechnology Research Institute (GEBRI), Sadat University, Sadat City, Egypt

³ Botany and Microbiology Department, Faculty of Science, Alexandria University, Alexandria, Egypt⁴
Botany Department, Faculty of Science, Mansoura University,, Egypt

Received: 20/11/2021
Accepted: 8/1/2022

Abstract: This study concentrates on evaluating the impact of cyanobacterium alga extract prepared from *Spirulina platensis* on seeds germination of (wheat) *Triticum aestivum* and (Lupin) *Lupinus termis*. Seeds of the previous plants were primed with *Spirulina* liquid extract (SLE) in 2.0% extract strength. In general, SLE induced the maximum positive magnitude of response in the following three germination parameters such as: length, weight, and counting of the germinating seeds for both *T. aestivum* and *L. termis*. The maximum counting of the germinating seeds (1.46 and 0.96) and weight the germinating seeds (0.83 and 1.87 g) and length the germinating seeds (6.36 and 3.87cm) of *T. aestivum* and *L. termis* seeds respectively, This study proves the effectiveness of (SLE) in functioning as a plant biostimulant for enhancing seed germination and growth parameters for *T. aestivum* and *L. termis*.

keywords: *Spirulina platensis* ; *lupinus termis* ; *Triticum aestivum*; germination parameters

1.Introduction

Microalgae provide plants with some fundamental nutrients and certain bioactive metabolites that stimulate growth of plant [1]. Florae getting microalgae treatment characterized with good growth giving improved -quality vegetables as indicated by Chiaiese et al. [2], and Coppens et al., [3]. Bumandalai and Tserennadmid, [4] found that germination percent of cucumber and tomato seeds was improved by Microalgae biofertilizer supplementation, whereas treatment with microalgal extract increased *Solanum lycopersicum* growth [5]. The application of cyanobacteria fertilizers may be wide distributed owing to being the simplest way for bio-fertilization as indicated by Cakmak, [6]. Cyanobacterial nourishments are effectual in rising micronutrient contents in wheat, rice and corn grains, that repel essential types of grain in terms of their economic value in livestock nutrition [7]. In agriculture and horticulture, poor seed germination performance has a great impact on germination, resulting in a large financial loss and lowering the yield of a given crop. Seed preparing with liquid algal extracts leads to improve seed growth in numerous crops such as wheat, rice,

canola, maize [8-10]. Seed primer is a seed enrichment technique that improves seed performance by quickly and uniformly germinating normal, healthy seedlings resulting in a faster and higher germination and emergence rates in different crops [11]. cyanobacteria are helpful for soil nutrient riding and can stimulate plant growth by civilizing nutrient obtainability [12, 13] and creating bioactive substances, such as phytohormones [14, 15], forming root associations [16] or protectects systems against phytopathogens and pests [17]. *Spirulina*, also identified as *Arthrospira platensis*, is a photosynthetic filamentous cyanobacteria that shows intense biomass productivity with the highest CO₂ fixation [18]. It has been found that the protein content of *Spirulina* varies between 50 and 70% of its dry biomass and exceeds meat, milk powder, eggs, soybeans or grain. *Spirulina* proteins contains completely fundamental amino acids are current constituting about 47% of the complete protein content composed mainly of leucine, valine as well as isoleucine as documented by Becker, [19], and Belay, [20]. The content of Lipid of *Spirulina platensis* and *Spirulina maxima* differs between

5.6 and 7%, respectively [21, 22], whereas lipid content may reach 11% by some adequate extraction systems as indicated by Hudson and Karis, [23] and Yoshida and Hoshi. [24]. Cohen, [25] demonstrated that 50% of the total lipids content of *Spirulina* composed of fatty acids. Fatty acids analysis of *Spirulina* lipid presented that polyunsaturated fatty acids (PUFAs) made up extreme proportion of complete lipid of 30%. *Spirulina* is ironic in γ -linolenic acid i.e. 36% of the total PUFAs and in addition delivers linoleic acid, stearidonic acid, eicosapentaenoic acid, docosahexaenoic acid and arachidonic acid [22]. In contrast, carbohydrates make up 15-25% of the dry weight of *Spirulina*. Simple carbohydrates, fructose, glucose and sucrose are available in very small quantities [26]. The main polymer component of *Spirulina platensis* is a branched polysaccharide, the glycogen is structurally similar. Anionic polysaccharides with high molecular weight with antiviral and immunomodulatory activities were also isolated from *Spirulina* [27, 28]. *Spirulina* devises the highest carbohydrate and elemental lipid content ever were found Cyanobacterium [29]. *Spirulina* is a blue-green cyanobacterium that has been used since olden times due to its special nutritious profile. It is rich in proteins, which constitute almost 60–70% of the dry weight, and also contains all the essential amino acids, a high proportion of carotenoids (6.25%) [30], essential fatty acids (gamma acid, linoleic acid, linolenic and palmitic acid), vitamins E, C and selenium [31].

S. platensis was used as an organic fertilizer for several plants in various application methods individually or in combination with other organic fertilizers [32]. *Spirulina* was applied directly to the floor or was increased in the form of an algae suspension. The application of *Spirulina* fertilizers is obstructed by the little charge, ready obtainability and preferred use of inorganic fertilizers. *Spirulina* contains 10% N w/w (the high amount is released slowly under normal soil conditions and increases fertility, meanwhile, Hussain et al., 2021 [33] suggested that microalgal extract could be low release fertilizer for vegetables.

The purpose of this study is to assess the influence of *Spirulina* liquid extract on the

germination parameters of both *Triticum aestivum* and *lupinus termis* by seed priming.

2. Materials and methods

Culturing conditions of *S. platensis*

The cyanobacterium *Spirulina platensis* (Nordstedt) Geitler (Oscillatoiales) was attained from the Culture Collection of the Algae laboratory, Faculty of Science, "Alexandria University", Egypt. *S. platensis* was cultivated in Zarrouk medium [34] with continuous illumination (35 $\mu\text{mol}/\text{m}^2/\text{s}$) at $28 \pm 2.0^\circ\text{C}$. After twenty four days of growth (in stationary phase), biomass was harvested by centrifugation at 3500 rpm, washed thoroughly with distilled water and then dehydrated at 60°C until stable weight.

Preparation of *S. platensis* liquid extracts

S. platensis liquid extract (2%) was prepared by macerating 2.0 g dry biomass in 100 ml distilled water then gently warmed at 50°C for 15 min with constant stirring. After cooling, the extract was filtered and stored at 4°C till use.

Bioassays of seed germination test under the influence of *S. platensis* Liquid extract (SLE)

Pure strains of the two plants; *Triticum aestivum* L and *lupinus termis* L were supplied by the Ministry of Agriculture, Field Crop Institute, Agriculture Research Center, Giza, Egypt. The uniform size, color and weight of the seeds were selected and surface sterilized using 0.01 % HgCl_2 for 3 min, then washed under running tap water for 10 min.

Bioassays of germination were carried out in accordance with the protocol of Hernández-Herrera [35]. Seeds of each plant of crops was found separately for 2 hours in both water (control) or of the planned extract, then seeds were let to germinate in 110-mm Petri plates on wetted Whatman No.3 two-layer filter papers for 2 days at $25 \pm 1^\circ\text{C}$ in dark, afterward photocycle of 16 hr. light/8 hr. dark for 5 days. Germination was recognized at radical emergence of 3 mm and recorded in 24 hr. intermissions. Throughout the experimental period the counting of germinated seeds was recorded, fresh biomass as well as radical length were determined [36, 37].

Statistical analysis:

Variance analysis (ANOVA) was used in the Statistical analysis System (SPSS 13.0 for windows). Significant differences among the average values were calculated by a multi-area test (LSD; Least Significant Difference). Therefore alpha (α) was 0.05 that corresponds to a level confidence of 95%.

3. Results

Bioassays of seed germination under the influence of *S. platensis* Liquid extract (SLE)

In all treatments, the breakage of the seed coat and the appearance emergence of radicals began at 24 hours. It was observed that seed priming induced significant stimulation response in all estimated germination criteria. Significant increments were detected in germinating seeds counting for both *T. aestivum* and *L. termis* (figure 1 a & b) relative to control.

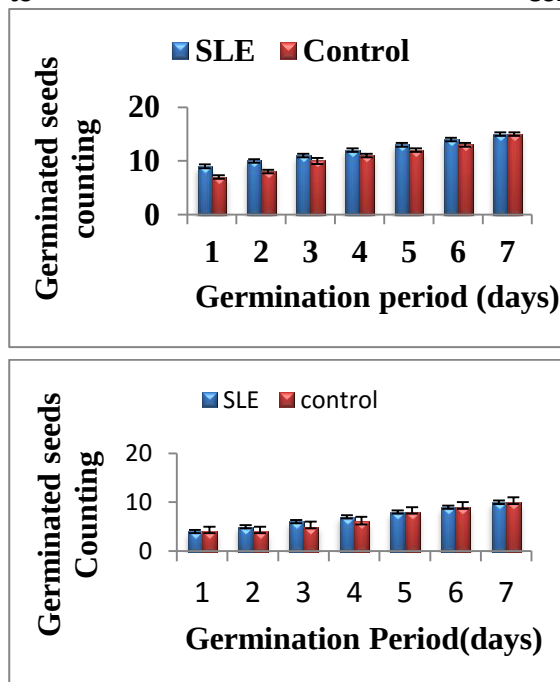


Figure 1 a & b: Counting of germinating seeds of *T. aestivum* (a) and *L. termis* (b) as affected by priming with SLE. Data represent mean $\pm$ SD. Different litters designate significant differences at ($P \leq 0.05$).

Priming seeds with SLE resulted in progressive marked increases in radicle length reaching the maximum value at the 7th day, 6.3 cm for *T. aestivum* seedlings and 3.87 cm for *L. termis* seedlings (Figure 2 a & b) relative to the hydro-primed seeds.

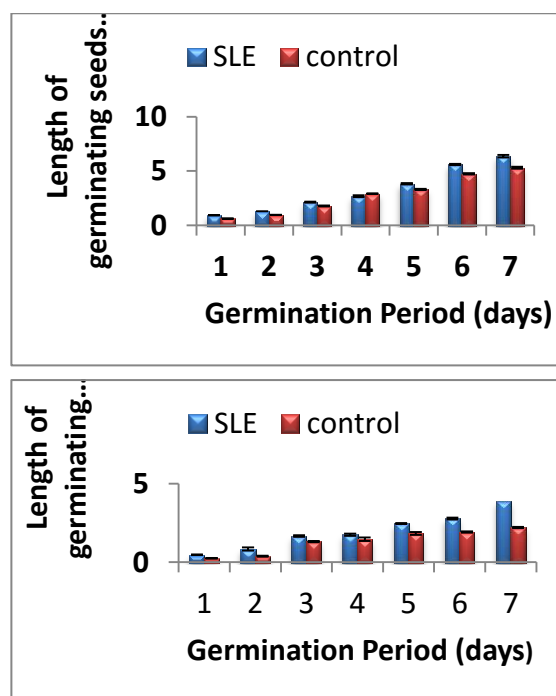


Figure 2a & b: Length of germinating seeds of *T. aestivum* (a) and *L. termis* (b) as influenced by priming with SLE.

Data represent mean $\pm$ SD. Different litters indicate significant differences at ($P \leq 0.05$). The same pattern of response was attained in case of germinating seeds biomass which exhibited progressive significant increases relative to hydro-primed seeds in the two investigated plants (Figure 3 a & b).

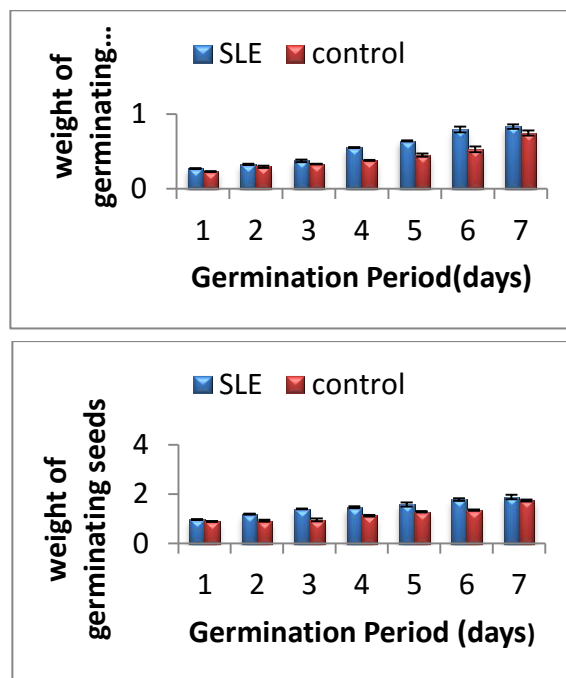


Figure 3 a & b: Germinating seeds biomass of *T. aestivum* (a) and *L. termis* (b) as influenced by priming with SLE. Data represent mean $\pm$

SD. Different litters indicate significant differences at ($P \leq 0.05$)

4. Discussion

The present study has shown that priming seeds of *T. aestivum* and *L. termis* with *S. platensis* extract (SLE) shows promising effects on germinating seeds counting, length of radical and weight of resulted seedlings of both plants. Present data demonstrated that seed growth encouraging properties of the SLE may improve plant growth and enhance crop yield in addition to confirm that the use of SLE is a smart and environmentally friendly technique to promote seed germination.

This study represented notable positive influences of *S. platensis* Liquid extract on the improvement of germination, radicle length and biomass of the tested seedlings. The obtained results are in a cord with that of many previous studies [38-40].

The detected stimulatory effect may be due to growth regulating capacity of *S. platensis* Liquid extract for example gibberellic acid ethylene and kinetin that include in accelerating germination time, improving growth and elaboration [41], in addition to the clarification of Battacharyya et al [42] and Sharma et al. [43], who attributed the obtained stimulatory effect to reducing growth inhibitors of seeds as abscisic acid that ameliorates the germination parameters.

In this regard, current results of promoting effect of SLE on *T. aestivum* and *L. termis* seed germination, ensuring the subsequent seedling organization and providing a confirming sustainable agricultural system. Many valuable outcomes have been reported after the use of microalgal extracts on plant growth improvement including germination enhancement, enhancing root development, promoting uptake of nitrogen and phosphorus as well as tolerance of higher biotic stress as reported by M  rigout [44] and Kumar et al. [45]. According to findings of Tarakhovskaya et al. [46], several hormone-like components as auxins, cytokinins, gibberellins, abscisic acid, brassinosteroids, jasmonic and salicylic acid were recognized in various algae and giving the same biological consequences that were found in higher plants as documented by Kiseleva et al. [47]. Increasing usage of

microalgae as biofertilizers may decrease the need for chemical fertilizers and thus demote the adverse environmental significances. It was found that Myanmar *Spirulina* biofertilizer could induce improving effect for the morphological growth parameters of *T. aestivum* and *L. termis* as reported by O'Connell. [48]. The growth promoting effect of microalgae extracts and suspensions was also investigated in field tests. For example, in *T. aestivum* and *L. termis* [49], sprayed varying amounts of supercritical extracts of *Arthrospira* (*Spirulina*) *platensis* containing naturally active combinations, including polyphenols, and attained grain crops similar to profitable biostimulants of plants .

In the current study it was discovered that the selective submission of cyanobacteria *S. platensis* as an organic fertilizer at a concentration 2 % stimulate growth of seedling in both legumes such as *T. aestivum* and *L. termis* also serves as an enhancer of seed germination and growth parameters (radical length) index in addition to weight of germinated seedling and number of germinated seeds [50]. The growth stimulation potential of *S. Platensis* (SLE) may be because SLE promoted micro and macro elements, vitamins, and more important growth hormones of Plants such as cytokinins [51, 52] In addition, chelating nutrients are reported to help improve of nutrient absorption due to the presence of some organic acids as in *Ascophyllum nodosum* [53].

Conclusion

In this study, *T. aestivum* and *L. termis* primed with of *S. platensis* liquid extract (SLE) (biological fertilizer) significantly increased germination of seeds, radical length and weight of germinated seeds. *Spirulina* Liquid Extract successfully promoted seedling growth.

5. References

1. Gon  alves, A.L. (2021). The use of microalgae and cyanobacteria in the improvement of agricultural practices: a review on their biofertilising, biostimulating and biopesticide roles. *Applied Sciences*. **11**, (2): 871.
2. Chiaiese, P., Corrado, G., Colla, G., Kyriacou, M.C. and Roupael, Y. (2018). *Renewable Sources of Plant*

- Biostimulation: Microalgae as a Sustainable Means to Improve Crop Performance. *Frontiers in plant science*. **9**: 1782.
3. Coppens, J., Grunert, O., Van Den Hende, S., Vanhoutte, I., Boon, N., Haesaert, G. and De Gelder, L. (2016). The use of microalgae as a high-value organic slow-release fertilizer results in tomatoes with increased carotenoid and sugar levels. *Journal of applied phycology*. **28**, (4): 2367-2377.
 4. Bumandalai, O. and Tserennadmid, R. (2019). Effect of *Chlorella vulgaris* as a biofertilizer on germination of tomato and cucumber seeds. *International Journal of Aquatic Biology*. **7**, (2): 95-99.
 5. Mutale-Joan, C., Redouane, B., Najib, E., Yassine, K., Lyamlouli, K., Laila, S., Zeroual, Y. and Hicham, E.A. (2020). Screening of microalgae liquid extracts for their bio stimulant properties on plant growth, nutrient uptake and metabolite profile of *Solanum lycopersicum* L. *Scientific reports*. **10**, (1): 2820.
 6. Cakmak, I. (2008). Enrichment of cereal grains with zinc: agronomic or genetic biofortification? *Plant and soil*. **302**, (1): 1-17.
 7. Hussain, S., Maqsood, M.A., Rengel, Z. and Aziz, T. (2012). Biofortification and estimated human bioavailability of zinc in wheat grains as influenced by methods of zinc application. *Plant and Soil*. **361**, (1): 279-290.
 8. Ghiyasi, M., Seyahjani, A.A., Tajbakhsh, M., Amirnia, R. and Salehzadeh, H. (2008). Effect of osmopriming with polyethylene glycol (8000) on germination and seedling growth of wheat (*Triticum aestivum* L.) seeds under salt stress. *Research Journal of Biological Sciences*. **3**, (10): 1249-1251.
 9. Ghiyasi, M., Myandoab, M.P., Tajbakhsh, M., Salehzadeh, H. and Meshkat, M. (2008). Influence of different osmopriming treatments on emergency and yield of maize (*Zea mays* L.). *Research Journal of biological sciences*. **3**, (12): 1452-1455.
 10. Rehmat, Y., Jabeen, R., Hameed, S. and EJAZ, M. (2021). Effects of cyanobacterium, *leptolyngbya* SP. and green microalga, *chlorella sorokiniana* as biofertilizers on in vitro seed priming and seedling growth of some economically important vegetables from pakistan. *Pakistan Journal of Botany*. **53**, (1): 343-350.
 11. Farooq, M., Basra, S., Wahid, A., Cheema, Z., Cheema, M. and Khaliq, A. (2008). Physiological role of exogenously applied glycinebetaine to improve drought tolerance in fine grain aromatic rice (*Oryza sativa* L.). *Journal of Agronomy and Crop Science*. **194**, (5): 325-333.
 12. Karthikeyan, N., Prasanna, R., Nain, L. and Kaushik, B.D. (2007). Evaluating the potential of plant growth promoting cyanobacteria as inoculants for wheat. *European Journal of Soil Biology*. **43**, (1): 23-30.
 13. Prasanna, R., Hossain, F., Babu, S., Bidyarani, N., Adak, A., Verma, S., Shivay, Y.S. and Nain, L. (2015). Prospecting cyanobacterial formulations as plant-growth-promoting agents for maize hybrids. *South African Journal of Plant and Soil*. **32**, (4): 199-207.
 14. Gheda, S.F. and Ahmed, D.A. (2015). Improved soil characteristics and wheat germination as influenced by inoculation of *Nostoc kihlmani* and *Anabaena cylindrica*. *Rendiconti Lincei*. **26**, (2): 121-131.
 15. Mazhar, S., Cohen, J.D. and Hasnain, S. (2013). Auxin producing non-heterocystous Cyanobacteria and their impact on the growth and endogenous auxin homeostasis of wheat. *Journal of basic microbiology*. **53**, (12): 996-1003.
 16. Bharti, A., Prasanna, R., Kumar, G., Kumar, A. and Nain, L. (2019). Co-cultivation of cyanobacteria for raising nursery of chrysanthemum using a hydroponic system. *Journal of Applied Phycology*. **31**, (6): 3625-3635.
 17. Roberti, R., Galletti, S., Burzi, P., Righini, H., Cetrullo, S. and Perez, C. (2015). Induction of defence responses in zucchini (*Cucurbita pepo*) by *Anabaena* sp. water extract. *Biological Control*. **82**: 61-68.
 18. Singh, S.K., Rahman, A., Dixit, K., Nath, A. and Sundaram, S. (2016). Evaluation of

- promising algal strains for sustainable exploitation coupled with CO₂ fixation. *Environmental technology*. **37**, (5): 613-22.
19. Becker, E.W. (2007). Micro-algae as a source of protein. *Biotechnology advances*. **25**, (2): 207-10.
 20. Belay, A. (2008). Spirulina (Arthrospira) production and quality assurance. In: Gershwin, E. and Belay, A. (eds.). *Spirulina in Human Nutrition and Health*. CRC Press, Taylor & France Group, Boca, Raton, London, New York, 1-23.
 21. Kay, R.A. (1991). Microalgae as food and supplement. *Critical reviews in food science and nutrition*. **30**, (6): 555-73.
 22. Habib, B., Parvin, M., Huntington, C. and Hasan, R. (2008). A review on culture, production and use of spirulina as food for humans and feeds for domestic animals and fish. *FAO Fisheries and Aquaculture Circular*. No. 1034. FAO, Rome.
 23. Hudson, B.J. and Karis, I.G. (1974). The lipids of the alga Spirulina. *Journal of the science of food and agriculture*. **25** (7): 759-63.
 24. Yoshida, M. and Hoshii, H. (1980). Nutritive value of spirulina, green algae, for poultry feed. *Japanese poultry science*. **17** (1): 27-30.
 25. Cohen, Z. (1997). The Chemicals of Spirulina. In: Vonshak, A. (ed.). *Spirulina platensis (Arthrospira) Physiology, Cell-Biology and Biotechnology*. Taylor and Francis, London, 175-204.
 26. Ciferri, O. and Tiboni, O. (1985). The biochemistry and industrial potential of Spirulina. *Annual review of microbiology*. **39**: 503-26.
 27. Parages, M.L., Rico, R.M., Abdala-Díaz, R.T., Chabrilón, M., Sotiroidis, T.G. and Jiménez, C. (2012). Acidic polysaccharides of Arthrospira (Spirulina) platensis induce the synthesis of TNF- α in RAW macrophages. *Journal of applied phycology*. **24**, (6): 1537-1546.
 28. Sotiroidis, T.G. and Sotiroidis, G.T. (2013). Health aspects of Spirulina (Arthrospira) microalga food supplement. *Journal of the Serbian Chemical Society*. **78** (3): 395-405.
 29. Morist, A., Montesinos, J., Cusido, J. and Godia, F. (2001). Recovery and treatment of Spirulina platensis cells cultured in a continuous photobioreactor to be used as food. *Process Biochemistry*. **37** (5): 535-547.
 30. Zahroojian, N., Moravej, H. and Shivazad, M. (2013). Effects of dietary marine algae (Spirulina platensis) on egg quality and production performance of laying hens. *Journal of Agricultural Science and Technology*. **15** (7): 1353-1360.
 31. Kalafati, M., Jamurtas, A.Z., Nikolaidis, M.G., Paschalis, V., Theodorou, A.A., Sakellariou, G.K., Koutedakis, Y. and Kouretas, D. (2010). Ergogenic and antioxidant effects of spirulina supplementation in humans. *Medicine & Science in Sports & Exercise*. **42**, (1): 142-51.
 32. Aly, M., El-All, A., Azza, A. and Mostafa, S.S. (2008). Enhancement of sugar beet seed germination, plant growth, performance and biochemical components as contributed by algal extracellular products. *Journal of Agricultural Science - Mansoura University*. **33** (12): 8429-8448.
 33. Hussain, F., Shah, S.Z., Ahmad, H., Abubshait, S.A., Abubshait, H.A., Laref, A., Manikandan, A., Kusuma, H.S. and Iqbal, M. (2021). Microalgae an ecofriendly and sustainable wastewater treatment option: Biomass application in biofuel and bio-fertilizer production. A review. *Renewable and Sustainable Energy Reviews*. **137**: 110603.
 34. Zarrouk, C. (1966). Contribution a l'etude d'une Cyanophyce. Influence de Divers Facteurs Physiques et Chimiques sur la croissance et la photosynthese de Spirulina mixima. University of Paris.
 35. Hernández-Herrera, R.M., Santacruz-Ruvalcaba, F., Ruiz-López, M.A., Norrie, J. and Hernández-Carmona, G. (2014). Effect of liquid seaweed extracts on growth of tomato seedlings (Solanum lycopersicum L.). *Journal of Applied Phycology*. **26**, (1): 619-628.
 36. Shariatmadari, Z., Riahi, H. and Shokravi, S. (2011). Study of soil blue-green algae and their effect on seed germination and

- plant growth of vegetable crops. *ROSTANIHA*. **12**, (2): 101-110.
37. Sadeghi, S., Rahnavard, A. and Ashrafi, Z. (2010). Allelopathic effect of *Helianthus annuus* on *Solanum nigrum* seed germination and growth in laboratory condition. *Journal of Horticultural Science and Ornamental Plants*. **2**, (1): 32-37.
 38. Garcia-Gonzalez, J. and Sommerfeld, M. (2016). Biofertilizer and biostimulant properties of the microalga *Acutodesmus dimorphus*. *J Appl Phycol*. **28**: 1051-1061.
 39. Liu, S., Li, B., Chen, X., Qin, Y. and Li, P. (2019). Effect of polysaccharide from *Enteromorpha prolifera* on maize seedlings under NaCl stress. *Journal of Oceanology and Limnology*. **37**, (4): 1372-1381.
 40. Selem, E. (2019). Physiological effects of *Spirulina platensis* in salt stressed *Vicia faba* L. plants. *Egyptian Journal of Botany*. **59**, (1): 185-194.
 41. Raghunandan, B., Vyas, R., Patel, H. and Jhala, Y. (2019). Perspectives of seaweed as organic fertilizer in agriculture. In: Panpatte, D. and Jhala, Y. (eds). *Soil fertility management for sustainable development*. Springer, Singapore, 267-289.
 42. Battacharyya, D., Babgohari, M.Z., Rathor, P. and Prithiviraj, B. (2015). Seaweed extracts as biostimulants in horticulture. *Scientia Horticulturae*. **196**: 39-48.
 43. Sharma, H.S., Fleming, C., Selby, C., Rao, J. and Martin, T. (2014). Plant biostimulants: a review on the processing of macroalgae and use of extracts for crop management to reduce abiotic and biotic stresses. *Journal of applied phycology*. **26**, (1): 465-490.
 44. Merigout, P. (2006). Étude du métabolisme de la plante en réponse à l'apport de différents fertilisants et adjuvants culturels. Influence des phytohormones sur le métabolisme azoté. PhD. Thesis. Institut National Agronomique Paris-grignon.
 45. Kumar, K., Sirasale, A. and Das, D. (2013). Use of image analysis tool for the development of light distribution pattern inside the photobioreactor for the algal cultivation. *Bioresource technology*. **143**: 88-95.
 46. Tarakhovskaya, E., Maslov, Y.I. and Shishova, M. (2007). Phytohormones in algae. *Russian Journal of Plant Physiology*. **54**, (2): 163-170.
 47. Kiseleva, A., Tarachovskaya, E. and Shishova, M. (2012). Biosynthesis of phytohormones in algae. *Russian Journal of Plant Physiology*. **59**, (5): 595-610.
 48. O'connell, P.F. (1992). Sustainable agriculture-a valid alternative. *Outlook on Agriculture*. **21** (1): 5-12.
 49. Michalak, I., Chojnacka, K., Dmytryk, A., Wilk, R., Gramza, M. and Rójs, E. (2016). Evaluation of Supercritical Extracts of Algae as Biostimulants of Plant Growth in Field Trials. *Frontiers in plant science*. **7**: 1591.
 50. Allakhverdiev, S.I., Sakamoto, A., Nishiyama, Y., Inaba, M. and Murata, N. (2000). Ionic and osmotic effects of NaCl-induced inactivation of photosystems I and II in *Synechococcus* sp. *Plant physiology*. **123** (3): 1047-56.
 51. Pramanick, B., Brahmachari, K. and Ghosh, A. (2013). Effect of seaweed saps on growth and yield improvement of green gram. *African Journal of Agricultural Research*. **8** (13): 1180-1186.
 52. Mohamed, A.Y. and El-Sehrawy, O.A. (2013). Effect of seaweed extract on fruiting of Hindy Bisinnara mango trees. *Journal of American Science*. **9**, (6): 537-544.
 53. Jannin, L., Arkoun, M., Etienne, P., Laîné, P., Goux, D., Garnica, M., Fuentes, M., San Francisco, S., Baigorri, R. and Cruz, F. (2013). Brassica napus growth is promoted by *Ascophyllum nodosum* (L.) Le Jol. seaweed extract: microarray analysis and physiological characterization of N, C, and S metabolisms. *Journal of plant growth regulation*. **32** (1): 31-52.