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RESEARCH

Consortium of microalgae/nitrogen-fixing bacteria as a next-generation biofertilizer, biostimulant and biopesticide

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Abstract

This study aims to provide insights into a new consortium of a microalga, twelve nitrogen-fixing (N-fixing) bacteria and a cyanobacterium. The microalga *Tetradesmus obliquus* (T), in conjunction with various N-fixing bacteria and the cyanobacterium *Synechocystis* sp. PCC 6803 (S), the N-fixing bacterium *Sphingobacterium* sp. L13G8 (5), cultivated in complete Bristol medium and in Bristol-$NaNO_3$ free conditions, were examined. The study encompassed the analysis of their consortia, including evaluation of their growth, and potential as a biostimulant, biofertilizer and biopesticide, and assessed for sedimentation performance for targeted applications. The T and N-fixing bacteria consortia had higher growth in Bristol $NaNO_3$-free media. The triple culture TS5 had the highest growth parameter (2.4 OD_{540}) in the same medium, followed by T5. The consortia were employed to ascertain the efficacy of their biostimulants and biofertilizers on watercress *(Lepidium sativum*) and to determine the potency of their biopesticides against the fungal pathogens *Fusarium oxysporum* and *Rhizoctonia solani* (in certain consortia). Consortium T5 demonstrated the most significant impact on the seeds germination index (212.7%) and root length (6.0 cm) of *L. sativum*. The same consortium had a significant impact on the shoot length (4.4 cm) of *L. sativum*. Among all consortia that were examined, T5 exhibited significant inhibitory effects on the growth of *F. oxysporum* (60.6%) and *R. solani* (69.2%). In the same consortium, the rate of microalgal biomass sedimentation was enhanced by the N-fixing bacterium (0.4 cm h^{-1}). Consortium T5 was the most effective in relation to growth and biomass sedimentation efficiency, in addition to its use as a biostimulant, biofertilizer and biopesticide. The created combination of microalga and N-fixing bacterium represents significant progress in the field of microalga cultivation, with notable benefits including improved biomass sedimentation and enhanced agricultural practices, as well as environmental friendliness and safety.

Keywords *Tetradesmus obliquus* · *Sphingobacterium* sp. · *Synechocystis* sp. · Biostimulant · Biofertilizer · Biopesticide · Biomass sedimentation

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Introduction

There is a significant interconnection between the domains of agriculture, climate change and poverty (IFAD 2024). The International Fund for Agricultural Development (IFAD) estimates that about 83.5% of global poverty is concentrated in rural communities, which are less likely to have access to adequate infrastructure, learning opportunities, basic resources and other essential services (health management and social security guarantee).

The agricultural sector plays a significant role in addressing global hunger and poverty. However, the enhanced agricultural efficiency was attained at the cost of the utilization of synthetic agrochemicals (fertilizers and pesticides), which are detrimental to the environment

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