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Acutodesmus dimorphus: A Promising Alga for Commercial Scale Cultivation for Biofuels and Biomass

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ABSTRACT

This article summarizes the potential of fresh water microalgae Acutodesmus dimorphus (A. dimorphus) for commercial scale cultivation. Recent studies on this alga are discussed. A recently concluded field trial of genetically modified strain of this alga, when cultivated outdoor in natural environment, demonstrated that the alga was able to express the modified phenotype with no observed adverse effect on native algal species in surrounding medium. Being first such US EPA approved evaluation of a genetically modified algae, this study has projected A. dimorphus as a promising GM alga that may now be taken up for industrial scale production. The article concludes by highlighting certain issues that need to be focused in order to make GM A. dimorphus a desirable strain for commercial scale cultivation.

Keywords: Acutodesmus dimorphus, genetically modified algae, environmental impact assessment of genetically modified algae.

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INTRODUCTION

For many decades algae have been recognised as potential biofactories for generating biomass in order to cater to the ever increasing demand for food and fuel. The photosynthetic potential of algae, fast growth rate that can be achieved in non-arable land, ability to grow in fresh/brackish/saline water, ability to sequester carbon dioxide from atmosphere/flue gas emissions and their ability to grow with minimal requirement for nutrients have made them researchers' choice [1]. Edible compounds or substances derived from algae reduce our dependence on food crops for feeding the fast-growing human population that has of late become consumption centric as well! In last few decades, productivity in food crops has largely been based on excessive use of fertilisers. Besides, in last few decades productivity in food crops has largely relied on indiscriminate use of fertilizers especially in developing countries. This has severely impacted the food chain. Since such adverse impacts may not arise in case of algae as their growth rate is up to 50 times more than the terrestrial plant and that algae can flourish in minimal supply of nutrients using nonpotable water, algae have gained acceptability as a potential source of food, animal feed and other value added products.

Studies on *A. dimorphus*

A feature that would facilitate commercial scale cultivation of *A. dimorphus*– a thermotolerant, fresh water [2], green microalgae known to be distributed across Europe [3–5], North America [6] and Africa [7] is the ability of non-GM counterpart to give higher yield of lipids, carbohydrates and biomass at higher temperature of 35°C as compared to 25°C. In one of the recent studies based on temperature dependent productivity in *A. dimorphus*, it was observed that during continuous cultivation the alga grew better at 35°C than at 25 and 38°C. At 35°C, *A. dimorphus* produced 22.7% lipid (containing 59% neutral lipid) and 33.7% carbohydrate along with 68% increase in biomass yield compared to the culture grown at 25°C [8].

This is important from the point of view of cultivation of this alga in tropical countries like India where outdoor temperature of around 35°C is not uncommon. In another recent study on the effect of salt stress on biomass and lipid yield in this fresh water alga has provided evidence of accumulation of carbohydrates and lipids. On addition of 200 mM NaCl to the culture during single stage cultivation, carbohydrate and lipid concentration was found to be 53.30 ± 2.76% and 33.40 ± 2.29% respectively while during two-stage cultivation salinity stress of 200 mM led to higher yield of biomass while increasing the salinity stress at same concentration led to an increase in lipid accumulation by 43% [9]. These attributes of *A. dimorphus* have been depicted in Figure 1.

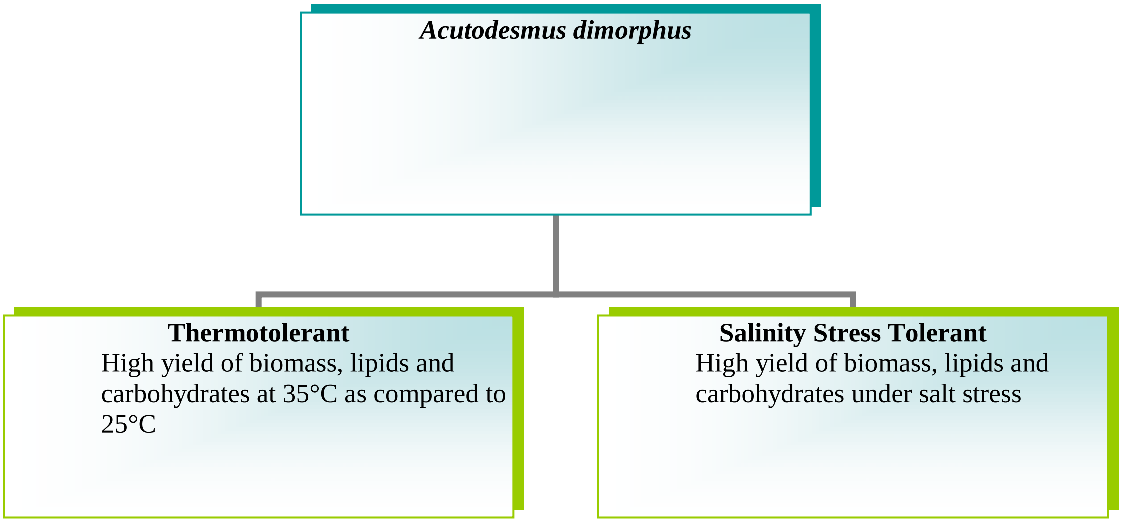

Fig. 1. *Attributes of A. dimorphus.*

Outdoor Field Trial of GM *A.dimorphus*

In addition, algae have shown to be amenable to genetic modification. This prompted various studies to genetically modify algae, especially microalgae, to increase the biomass and lipid production (used for producing biodiesel through transesterification). In a recent 50 day-field trial funded by the US department of Energy and sanctioned by the U.S. Environmental Protection Agency (EPA), the genetically modified (GM) strain of *A. dimorphus* has shown that the it was able to express the modified phenotype with no observed adverse effect on other native species of algae.

The GM strain was engineered with genes for fatty acid synthesis and green fluorescent protein. The study is reported to be the first of its kind wherein a GM algal strain has been studied in natural ecosystem for its sustainability and its impact on native algal species in its surrounding [10]. It was observed that neither the GM strain nor its wild type counterpart could outcompete the native strains (Figure 2).

This was in contrast to the speculation generally spread against GM organisms that during domestication or their dispersal in natural environment GM strains may adversely affect the growth of native species [11, 12]. This study has projected *A. dimorphus* as a potential GM alga that may now be taken up for commercial scale cultivation after due approvals.

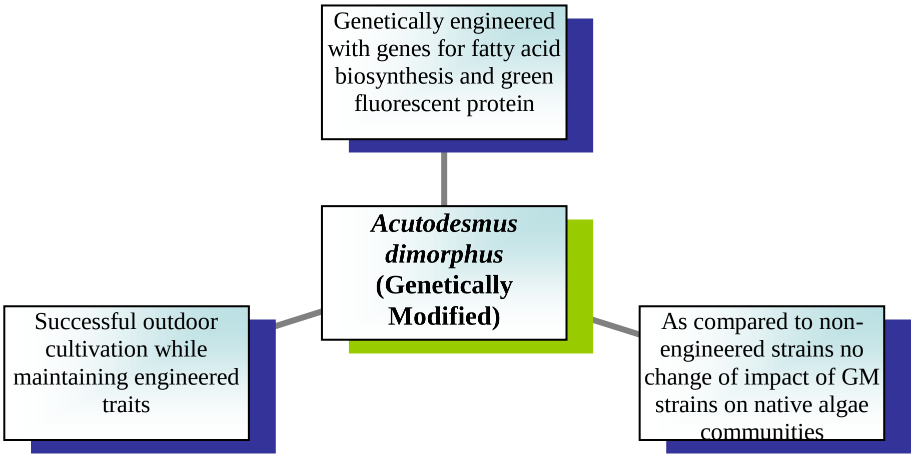

Fig. 2. *Attributes of recently tested genetically modified A. dimorphus.*

CONCLUDING REMARKS

Though many studies of genetic modification on algae have been performed earlier at lab scale but due to lack of environmental impact assessment studies, a GM alga suitable for commercial scale cultivation for providing feedstocks for food and fuel was elusive. Recent US EPA approved studies on both wild type and GM *A. dimorphus* have raised the hope that this alga may be employed for commercial scale production of biofuels and biomass.

However, there are certain issues that need to be focused in order to make GM *A. dimorphus* a desirable strain for commercial scale cultivation. One aspect that needs to be focused is minimising the costs involved in algae harvesting as up to 20–30% of the cost of production of biodiesel goes in harvesting [13]. Besides, as culturing algae in raceway ponds is generally adopted in an industrial setup in order to minimise the cost, it is important that the GM strain should also be a robust one, one that can resist infections by probable pathogens [14]. So, the newly developed GM *A. dimorphus* should also be evaluated on this front and if required should be strengthened through adequate domestication.

Another aspect that may be looked into is that whether instead of using pure culture a polyculture approach must be evaluated for GM *A. dimorphus* as it is now widely accepted that increase in species diversity may be instrumental in increasing the biomass and lipid yield [15–18]. This is easier said than done and it is advisable to start production with monoculture till the time such polyculture approach is optimized for still higher yields.

Competing Interests
The authors have no conflict of interest.

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