Effect of *Spirogyra fluviatilis* on Seed Germination of *Daucus carota* L. Var. Maverick and Choctaw

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KEYWORDS

Carrot seeds
Freshwater algal fertilizer
Growth media
Germination percentage
Seedling growth

ABSTRACT

Daucus carota L. (Carrot), a root vegetable of the Umbelliferae family, is widely cultivated and offers several health benefits. Algae, rich in plant nutrients, are increasingly used as natural biofertilizers to reduce the harmful effects of synthetic fertilizers. This study, conducted at the Phycology Lab, Department of Botany, GCU, Lahore, investigates the effect of freshwater algae on seed germination in two carrot varieties, var. Choctaw and Maverick. Four concentrations of *Spirogyra fluviatilis algal* extract (0 %, 10 %, 50 %, and 100 %) were tested, with parameters including shoot length, root length, leaf number, and leaf length. Statistical analysis using ANOVA and the Least Significant (LSD) test revealed that algal extract concentration significantly affected growth parameters, with maximum growth observed in the control group and minimum growth at 100% algal extract. No significant differences were found between the 10 % and 50 % concentrations. Variety type did not significantly influence the growth parameters.

1. Introduction

Carrots, a popular vegetable in Pakistan, are grown at an average yield of 17.5 tons per hectare, which is lower than in top-producing countries like Belgium, Denmark, the UK, China, and India (Ahmad *et al.*, 2012). This gap may be due to the less advanced agricultural practices.

Carrots offer numerous health benefits, including boosting the immune system, regulating metabolism, promoting healthy skin and eyes, and reducing the risk of high blood pressure, stroke, heart disease, and certain cancers. Carrot farming is gaining popularity among farmers in Punjab Province, where it is now recognized as a successful and profitable business (Butt *et al*., 2007).

Several factors influence algae growth, with light and temperature being the most important. Algae rely on chlorophyll pigments to absorb sunlight, making solar radiation essential for growth in ponds and lakes. Most algae species thrive best at temperatures between 20 and 30 °C. Light intensity ranges from 33 mol m^{-2} s^{-1} to 400 mol m^{-2} s^{-1} for optimal growth (Singh and Priyanka, 2015).

Freshwater algae provide significant agricultural benefits. They can be used as fertilizers to enhance soil fertility and productivity, offering a rich source of micro and macronutrients. Algal extracts also act as bio stimulants, boosting seed germination, crop quality, and overall yield (Sengar *et al.*, 2010).

Blue-green algae (Cyanobacteria) play a vital role in freshwater and terrestrial ecosystems by fixing atmospheric nitrogen, enhancing soil fertility, and providing essential nutrients for plant growth. They form protective mats that reduce erosion and evaporation, while their mucilage binds soil particles together (Venkataraman and Neelakantan, 1967).

The overuse of synthetic chemicals in agriculture has led to soil infertility, ocean dead zones, and biodiversity loss. In contrast, biofertilizers, including microalgae and cyanobacteria, are cost-effective, environmentally friendly, and provide a sustainable alternative to pesticides, boosting productivity while reducing pollution (Chagnon *et al*., 2015).

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Photosynthetic organisms like *Chlorella vulgaris* (green algae) and *Spirulina platensis* (blue-green algae) are valuable biofertilizers, rich in proteins, vitamins, amino acids, and fatty acids. They enhance crop yields and quality by providing growth-promoting substances such as phytohormones, vitamins, and amino acids (Mulbry *et al*., 2008). Phototrophic biomass, like cyanobacteria and microalgae, provides bioactive compounds that enhance plant growth and convert nutrients into accessible forms, making biological fertilizers highly effective for soil fertility and plant development (Tripathi *et al*. 2008).

Microalgae (*Acutodesmus dimorph*, *Chlorella vulgaris*) and cyanobacteria (*Nostoc ellipsosporum*, *Anabaena oryzae*, *Synechococcus* sp.) produce bioactive compounds that promote plant growth. Crops like barley, oats, tomatoes, radishes, cotton, sugarcane, maize, chili, and lettuce benefit from cyanobacterial inoculation (Thajuddin and Subramanian, 2005). *Phormidium* sp. cyanobacteria enhances rice seed germination, root and shoot growth, and grain quality through bioactive compounds like auxins, amino acids, carbohydrates, and vitamins (Svircev *et al*., 1997).

This study was conducted to explore the potential of *Spirogyra fluviatilis*, a freshwater alga, as a natural and sustainable agent influencing plant growth and development, particularly in carrot seed germination. With the increasing demand for organic and ecofriendly agricultural practices. The current study investigates the effect of different concentrations of *Spirogyra fluviatilis* extract on carrot seed germination and compare the germination rates of carrot varieties (Maverick and Choctaw) treated with *Spirogyra fluviatilis* extract.

2. Materials and methods

2.1 Algal Collection

Freshwater algae were hand-collected from a pond at the Botanical Garden, Government College University Lahore, and transported to the Phycology lab in polythene bags.

2.2 Drying and powdering

Algae were dried for3-4 days, resulting in 158.5 g of dried algae and150 g of powdered algae.

2.3 Seed Collection

Carrot seeds (Maverick and Choctaw varieties) were sourced from the Federal Seed Certification Department, Lahore.

2.4 Identification of Algae

Algae were preserved in 4 % formalin and identified as *S. fluviatilis* under a 40 x microscope.

2.5 Seed Viability Test

Seeds were soaked in distilled water; viable seeds sank, non-viable ones floated.

2.6 Preparation of Algal Extract

12.5 g of powdered algae was dissolved in 1000 mL of distilled water, autoclaved, and then prepared in 10 %, 50 %, and 100 % concentrations.

2.7 Experimental Setup

24 sterilized petri plates were prepared with blotting paper. Seeds of each variety (Maverick and Choctaw) were treated with the respective algal extract concentrations. Plates were incubated at room temperature for two weeks, with readings taken every 3 days.

2.8 Statistical Analysis

Data were analyzed using SPSS version 16 with two-way ANOVA LSD. Results are presented as mean ± SD, with $P < 0.05$ considered significant.

3. Results

The Algal extract was utilized as liquid biofertilizer for seedling germination of carrot plant. Effect of this biofertilizer was tested on some parameters of germinated seedlings. These parameters include shoot length, root length, total height, leaf number, number of adventitious roots, and germination percentage of both carrot seed varieties as shown in (Table 1).The Maverick variety showed 99.80 % germination rate, compared to 87.50 % for the Choctaw variety. This indicates that Maverick seeds responded better to the application of *S. fluviatilis* algal extract than Choctaw seeds.

3.1 Effect of different concentrations of algal extract on various parameters of carrot seedlings

The relationship between mean shoot length and algal extract concentration is shown in (Figure.1). *Daucus carota* L. var. Maverick showed maximum growth (2.79 cm) in control; while var. Choctaw showed maximum growth (2.36 cm) at 10 % algal extract concentration. Both varieties showed minimum growth at 100 % concentration level.

A two-way ANOVA was conducted to examine the effects of *Spirogyra fluviatilis* extract concentration and variety type (Maverick and Choctaw) on the shoot length of *Daucus carota* L. The results revealed a significant statistical effect of *Spirogyra fluviatilis* extract concentration on the shoot length ($p = 0.00$), whereas variety type had no significant effect on the plant growth ($p = 0.81$). Due to significant differences among concentration levels, An LSD test was conducted to compare concentration levels to the control.

Concentration level of 100 % and 50 % *S, fluviatilis* extract showed significantly different germination as compare to the control and 10 % *S. fluviatilis* extract concentration level showed similar germination as Control at ά = 0.05.

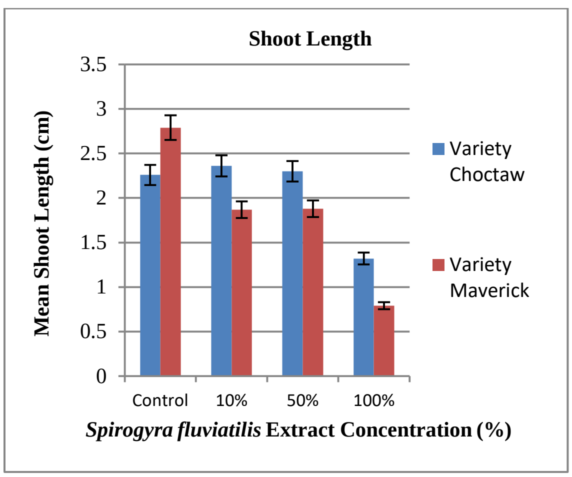

Fig. 1. Effect of different concentrations of *S, fluviatilis* extract on shoot length of carrot seedlings for two varieties (Maverick and Choctaw). Bars represent mean shoot length (cm) under Control (0%), 10 %, 50 %, and 100 % extract concentrations. Error bars indicate standard error. Both varieties showed maximum shoot length in the control and minimum at 100 % concentration.

The relationship between mean root length and varying concentration of algal extract is shown in (Figure 2). *Daucus carota* L. var. Choctaw had maximum root length (4.31 cm) in control and minimum (0.62 cm) at 100 % concentration. Var. Maverick had maximum root length (3.91 cm) in control and minimum (1.27 cm) at 100 % concentration.

A Two-way ANOVA to analyze the effect of algal extract concentration and variety type (Maverick and Choctaw) on the root length of *Daucus carota* L. was used. The analysis showed algal extract concentration levels had significant statistical effect on the plant growth ($p= 0.00$) while variety type had no significant statistical effect on plant growth ($p= 0.61$). An LSD test was conducted to identify concentration levels with significant differences from the control.

Concentration levels of 50 % and 100 % algal extract showed significantly different germination as compare to the control, while 10 % algal extract concentration level showed similar germination as control ά = 0.05.

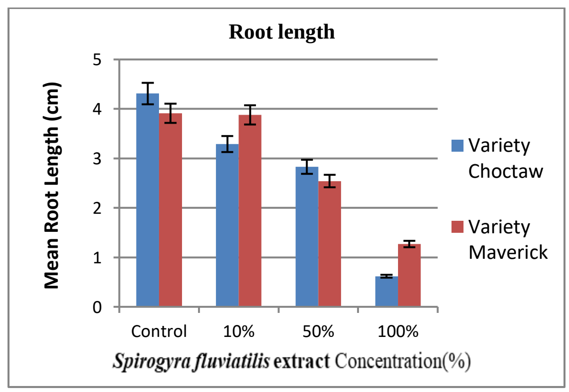

Fig. 2. Effect of different concentrations of *S. fluviatilis* extract on root length of carrot seedlings for two varieties (Maverick and Choctaw). Bars represent mean root length (cm) under Control (0 %), 10 %, 50 %, and 100 % extract concentrations. Error bars indicate standard error. Both varieties showed maximum root length in the control and minimum at 100 % concentration.

The relationship between leaf number and varying concentration of algal extract is shown in (Figure 3). *Daucus carota* L. var. Choctaw had maximum leaf number (1.78) in control and minimum (0.78) at 100 % concentration. Var. Maverick had maximum leaf number (1.89) in control and minimum (1.56) at 100 % and 50 % concentrations.

A two-way ANOVA revealed that *S. fluviatilis* extract concentration significantly affected leaf number ($p = 0.01$), but variety type (Maverick and Choctaw) had no significant effect (p = 0.06). An LSD test identified concentration levels with significant differences from the control.

Concentration levels of 100 % *S. fluviatilis* extract showed significantly different germination as compare to the control, while 10 % and 50 % algal extract concentration level showed similar germination as control ά = 0.05.

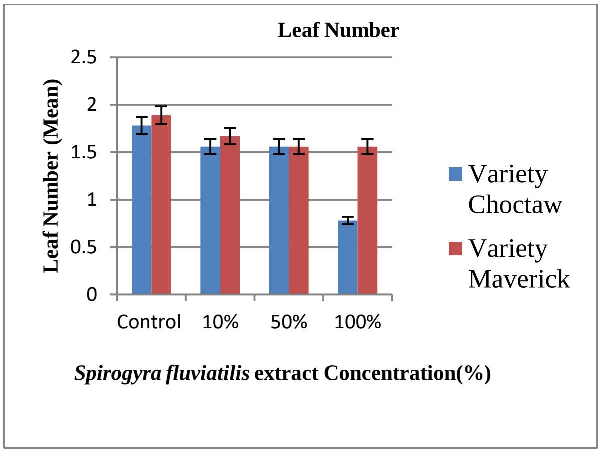

Fig. 3. Effect of different concentrations of *Spirogyra fluviatilis* extract on leaf number of carrot seedlings for two varieties (Maverick and Choctaw). Bars represent mean leaf number under Control (0%), 10 %, 50 %, and 100 % extract concentrations. Error bars indicate standard error. Both varieties showed maximum leaf number in the control and minimum at 100 % concentration.

Table 1. Germination percentage of carrot seed varieties

Varieties	Germination
Variety Choctaw	87.50%
Variety Maverick	95.80%

The relationship between leaf length mean and varying concentration of algal extract is shown in (Figure 4). *Daucus carota* L. var. Choctaw and Maverick showed maximum leaf length in control (0.99 cm and 0.85 cm, respectively) and minimum leaf length at 100% *S. fluviatilis* extract concentration (0.36 cm and 0.51 cm, respectively).

Two-way ANOVA to analyze the effect of *S. fluviatilis* extract concentration and variety type (Maverick and Choctaw) on leaf length of *Daucus carota* L. was used. The analysis showed algal extract concentration levels had significant statistical effect on the plant growth (p= 0.00) while variety type had no significant statistical effect on the plant growth (p= 0.11). As there are significant differences found among the groups of concentration levels. So, LSD test was carried out to determine which concentration levels are significantly different from the control.

Concentration levels of 100 % *S. fluviatilis* extract showed significantly different germination as compare to the control, while 10 % and 50 % algal extract concentration level showed similar germination as control ά = 0.05.

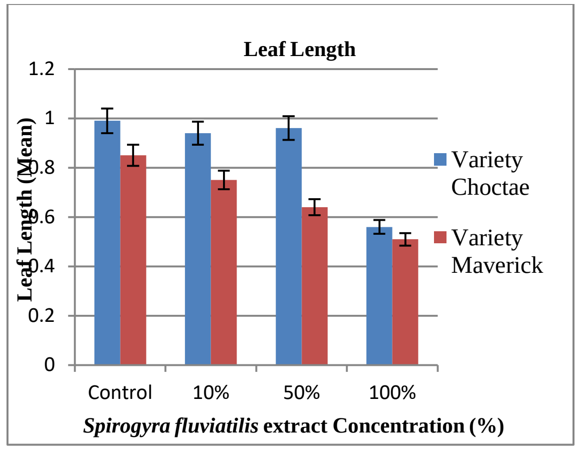

Fig. 4. *Spirogyra fluviatilis* extract of different concentrations (Control, 10 %, 50 %, 100 %) on leaf length of carrot seedling.

4. Discussion

Freshwater algae are used as a biofertilizer in many crops in different parts of the world and reduce pollution. Freshwater algae have growth enhancing activities because they contain micronutrients, macronutrients, amino acids, proteins and growth regulators such as auxin, cytokinin etc. (Hullur *et al*., 2016).

The goal of the current research is to investigate the effect of *S. fluviatilis* extract on carrot seed germination. The extract was applied to Maverick and Choctaw seeds at various concentrations (10 %, 50 %, and 100 %), with distilled water serving as the control. Two-way ANOVA results showed significant differences between treated and control groups in germination percentage of varieties (Maverick and Choctaw) seeds and shoot length, root length, leaf number, and leaf length of carrot seedling.

According to Brahmbhatt and Kalasariya (2015) in plate culture of alfalfa plant, the seeds treated with *Oscillatoria sp*. and *Spirogyra* sp. showed maximum plant height, leaf numbers and radical length than control (distilled water). *Spirogyra* sp. had greater favorable effects on the vegetative characteristics of the alfalfa plant than did *Oscillatoria* sp., which had less of an impact. The results showed that in *Daucus carota* L. var. *Maverick*, the maximum germination percentage (99.80 %) and shoot length (2.79 cm), root length (3.91 cm), leaf number (1.89), and leaf length (0.85 cm) occurred at the control, while the minimum values were at 100 % *S. fluviatilis* extract shoot length (1.82 cm), leaf length (0.51 cm), leaf number (1.56), root length (1.27 cm). In *Daucus carota* L. var. *Choctaw*, the maximum germination percentage (87.50 %) and shoot length (2.36 cm) was at 10 % algal concentration, root length (4.31 cm), leaf number (1.78), and leaf length (0.99 cm) at control, with minimum values at 100 % extract shoot length (0.79 cm), root length (0.62 cm), leaf number (0.78), leaf length (0.36 cm). The germination rate of seeds suggests that the Maverick variety exhibited a more favorable response to the application of *S. fluviatiles* algal extract as compared to the Choctaw, indicating its higher potential for improved seed vigor and early establishment under the given treatment conditions

According to Mahadik and Jadhav (2015), tomato seeds treated with *Spirogyra jugalis* extract showed 80% germination, with 6.5 cm shoot and 5.1 cm root lengths, compared to 60 % germination and 5.5 cm shoot and 4.8 cm root lengths in control. *S. jugalis* enhanced tomato growth, unlike *S. fluviatilis*, where the control showed the maximum growth and 100 % extract resulted in the minimum growth in carrot seedling.

5. Conclusion

The result of the experiment showed that there is a significant difference in shoot length, root length, leaf number and leaf length as compare to control. The variety Maverick and Choctaw carrot seeds showed maximum growth in control and minimum growth at 100 % *S. fluviatilis* concentration while almost same growth at 10 % and 50 % *S. fluviatilis* concentration. According to the recent studies, freshwater algae produce growth-promoting substances, such as phytohormones and micronutrients, which may contribute to enhanced plant development and yield. These findings indicate that *S. fluviatilis* has potential as a biofertilizer when applied at lower concentrations, promoting plant growth without the inhibitory effects seen at full strength. This highlights its possible application in sustainable agriculture as an eco-friendly alternative to synthetic fertilizers.

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7. References

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