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Effect of Soaking Tomato Seeds in Spirulina *Arthrospira platensis* and Yeast *Saccharomyces cerevisiae* Suspensions on Germination: An Experimental Study

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Abstract

The use of natural alternatives, such as microbes, to support seed germination is becoming more important as farmers seek eco-friendly ways to grow crops. This study examined how soaking tomato seeds in Spirulina or yeast suspensions affect their germination. Methods: Tomato seeds were soaked in Spirulina, yeast, or distilled water for 24 h as controls. The seeds were then placed in Petri dishes and observed for nine days to record how well and how fast they germinated. Results: Seeds soaked in Spirulina had the best results, with a 96% germination rate and faster growth. The yeast group performed better than the control group, with the lowest rate (70%). Conclusion: Soaking tomato seeds in Spirulina or yeast improved germination. Spirulina yielded the best result. These natural treatments could be useful in farming; however, more tests using different amounts and real field conditions are needed.

Keywords

Germination, Spirulina, Yeast, Tomato Seeds, Biofertilizer

1. Introduction

Microorganisms are essential for maintaining soil health and plant growth. Therefore, microbial fertilizers composed of bacteria and fungi have been explored as environment-friendly alternatives that promote natural plant growth and replace synthetic fertilizers, which are overused and detrimental to crops [1]. When examining the role of microbial fertilizers in crops, it is important to focus on their

effect on germination, which is defined as the process by which a dormant seed resumes metabolic activity and begins to develop into a seedling. This process begins when the dry seed absorbs water and ends with the elongation of the embryonic axis. This is a critical stage in the plant life cycle as it determines the success of establishing a new plant. Many factors influence germination, including availability of water and oxygen, temperature, and light [2]. Numerous studies have been conducted on the use of cyanobacteria and microalgae as biofertilizers and growth promoters, with positive results. For example, cyanobacteria have been shown to secrete growth promoters such as auxins, cytokinins, and gibberellins into their extracellular polymeric substances (EPS) [3]. These chemicals play key roles in regulating plant growth, metabolism, and development.

Research has also suggested that soaking seeds in cyanobacterial suspensions enhances water uptake, helping to create ideal conditions for seed inoculation and colonization. This stimulates seed germination and increases the seedling growth.

Spirulina, a tiny blue-green unicellular alga classified as a cyanobacterium, is an example of a cyanobacterium. This alga is typically found in freshwater and saltwater environments, and is known for its agricultural benefits. Spirulina secretes extracellular polymers that improve soil water retention. This enhances water-use efficiency.

Spirulina properties also help improve soil quality and promote beneficial microbial activity in the root zone. The EPS produced also facilitates seed colonization, thereby enhancing germination under harsh environmental conditions. In addition to improving germination, Spirulina also enhances early root growth by stimulating auxin production and water absorption. Extracellular polysaccharides promote soil aggregation and microbial colonization, creating a protective environment around the seeds [3]. These properties make Spirulina particularly useful in less-than-ideal conditions, enhancing seedling vigor and stress tolerance.

Through these mechanisms, Spirulina can partially improve plant growth, thereby contributing to the synthesis and inhibition of moisture in water-constrained areas.

In addition to Spirulina, fungi are another example of microorganisms that can influence germination and promote plant growth, particularly yeast, a single-celled microorganism classified in the kingdom of fungi. It reproduces by budding or binary fission and is widely distributed in various environments including soil, plants, and water.

Yeast plays important roles in many biological processes, including promoting plant growth, improving soil health, and enhancing plant growth and stress resistance.

Some strains produce growth regulators such as indole-3-acetic acid (IAA) and gibberellins, which stimulate root elongation and seedling establishment. Additionally, yeast helps solubilize phosphate, improve nutrient bioavailability, and release ammonia, which improves soil fertility. Yeast also improves microbial balance in the root zone by producing siderophores, which contribute to iron seques-

tration and inhibit plant pathogens [4]. Additionally, its enzymatic activity enhances the decomposition of organic matter, thereby improving the availability of nutrients for seed germination. These functions contribute to better seedling establishment and resilience during the early stages of growth [1].

Agricultural efficiency is affected by carbon source availability, temperature, and microbial competition.

In summary, yeast is beneficial for agriculture as an alternative to chemicals [4].

In addition to the benefits of agriculture, yeast and Spirulina contain many highly beneficial nutritional elements. A study confirmed that Spirulina contributes significantly to public health by reducing harmful cholesterol, supporting liver function, and weight loss [5].

It is an iron-rich food source that is beneficial to humans. This supports the development of foods rich in probiotics and prebiotics in the digestive system [6].

Yeast is a living organism known for its ability to support digestive and immune systems. It provides essential vitamins and minerals to the human body. Yeast is also involved in the manufacture of antibiotics and cancer treatment. [7].

It also contributes significantly as a protein source and nutritional supplement to humans and animals. They are also widely used in the food industry. Yeast proteins recycle materials, such as waste, and preserve the environment. Recognizing the benefits of yeast among consumers improves their quality of life and prevents disease [8].

In this study, we investigated the effects of soaking tomato seeds in S. platensis and S. cerevisiae suspensions on germination.

This study aimed to evaluate the effect of soaking in yeast and Spirulina suspensions on germination compared with no treatment. Despite their proven potential, direct comparisons between Spirulina and yeast on seed germination, especially in uncontrolled environments, are limited.

This study hypothesizes that soaking tomato seeds in Spirulina or yeast suspensions enhances germination compared with untreated seeds.

To test this hypothesis, the experimental groups were divided as follows:

- Seeds soaked in Spirulina suspension.
- Seeds soaked in yeast suspension.
- Seeds soaked in distilled water were used as controls.

2. Material and Methods

This experiment was conducted at home under simple and consistent conditions to evaluate the preliminary effects of Spirulina and yeast suspensions on tomato seed germination. The temperature during the experiment was set to approximately 25˚C, and all Petri dishes were placed in a dark, quiet area to simulate standard germination conditions. Given the home-based setting, it was not possible to precisely control environmental variables, such as humidity and airflow, which is a limitation of this study. However, efforts were made to maintain similar conditions for all treatments to ensure consistency and minimize bias.

This study evaluated the effects of yeast and Spirulina suspensions on germination, particularly the germination of tomato seeds under controlled conditions at home. Seeds were soaked in suspensions or distilled water as a control. After soaking for 24 h, the seeds were transferred to sterile 9 cm Petri dishes covered with filter paper. Each group contained five dishes each containing 10 seeds and 5 ml of distilled water, to preserve the humidity level of the dish. Seed germination was observed for 9 d at 25˚C in the dark. Seeds were considered to have germinated when the radicle reached a minimum diameter of 2 mm.

2.1. Yeast Suspension Preparation

Commercial baker's yeast Saccharomyces cerevisiae, which is available in the local market, was used to prepare the suspension. Yeast (5 g) was dissolved in 1000 ml of distilled water and 5 g of sugar was added to activate the yeast as a source of carbon and nitrogen. The suspension is left for 12 hours at 25˚C before using [9] [10].

2.2. Spirulina Suspensions Preparation

Dried S. platensus produced by (Nutrex Hawaii) was used to prepare the suspensions. Two grams of it were dissolved in 100 ml of distilled water, heated at 50˚C, and stirred for 60 min. The suspension was filtered, cooled, and stored at 4˚C until use [11].

2.3. Seed Treatment and Experimental Design

Tomato seeds Solanum lycopersicum were soaked in three treatment groups (yeast, Spirulina, and distilled water) for 24 h [12]. Subsequently, they were transferred to Petri dishes covered with filter paper, and 10 seeds were placed in each dish [13] [14]. The dishes were left in the dark at 25˚C, and 5 ml of distilled water was added to each dish [15] [16]. All groups contained five replicates of Petri dishes [14].

2.4. Germination Assessment

Seed germination was recorded for nine days, and seeds were considered germinated when the radicle length reached 2 mm [17].

2.5. Study of Germination of Seeds Soaked in Different Suspensions

A germination study was conducted on tomato seeds soaked in the various suspensions. Daily observations were recorded based on the emergence of radicals.

By the following formula the seeds germination percentage calculated [18]:

$$\text{Germination } \% = \text{Number of germinated seeds}/\text{Total number of seeds} \times 100$$

Germination associate parameters were calculated by using following formulas given by [18] [19].

1) Speed of germination

The speed of germination was calculated using the following formula:

$$\text{Speed of germination} = n1/d1 + n2/d2 + n3/d3 +$$

where, n = number of germinated seeds, d = number of days.

2) Mean germination Time (MGT)

Mean germination time was calculated by the formula:

$$\text{MGT} = \frac{n1 \times d1 + n2 \times d2 + n3 \times d3 + \cdots}{\sum n}$$

where, n = number of germinated seed d = number of days $\sum n$ = total number of germinated seed.

2.6. Statistical Analysis

Data were analyzed using one-way ANOVA in SPSS. The means of the different treatment groups were compared to assess differences in germination percentage, speed, and time. No post-hoc tests were conducted, and assumptions such as normality and homogeneity of variances were not tested due to the small sample size and exploratory nature of the study.

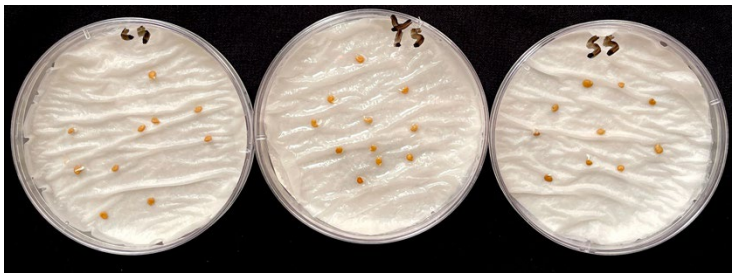
3. Result

Tomato seed germination was monitored for nine days across three treatments: Spirulina, yeast, and control. The daily germination count is presented in (Table 1), which shows faster and more consistent germination in the Spirulina group starting on day 3.

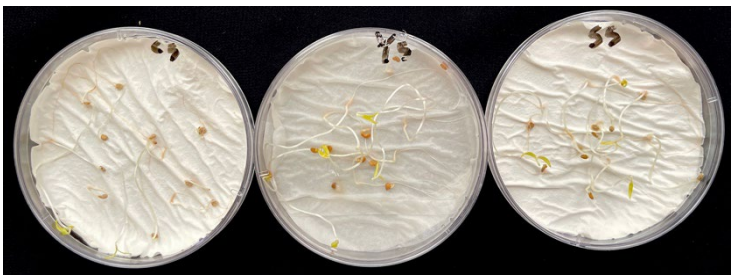
Table 1. Germination data for seeds treated with suspensions over the days.

Day	Control Group (Plate 1)	Control Group (Plate 2)	Control Group (Plate 3)	Control Group (Plate 4)	Control Group (Plate 5)	Total Germinated (Control)	Yeast Group (Plate 1)	Yeast Group (Plate 2)	Yeast Group (Plate 3)	Yeast Group (Plate 4)	Yeast Group (Plate 5)	Total Germinated (Yeast)	Spirulina Group (Plate 1)	Spirulina Group (Plate 2)	Spirulina Group (Plate 3)	Spirulina Group (Plate 4)	Spirulina Group (Plate 5)	Total Germinated (Spirulina)
3	2	1	1	2	3	9	3	6	5	2	4	20	8	8	3	5	2	26
4	2	3	3	3	1	12	1	2	4	3	4	14	2	1	6	3	6	18
5	1	3	1	2	2	9	3	-	1	-	2	6	.	-	-	-	2	2
6	-	1	-	-	2	3	-	-	.	2	-	2	.	-	1	-	.	1
7	-	-	1	-	1	2	-	-	.	-	.	-	.	1	.	-	.	1
8	-	-	-	-	-	-	-	-	.	-	.	-	.	-	.	-	.	-
9	-	-	-	-	-	-	1	-	.	-	.	1	.	-	.	-	.	-
Total germination seed	**5/10**	**8/10**	**6/10**	**7/10**	**9/10**	**35/50**	**8/10**	**8/10**	**10/10**	**7/10**	**10/10**	**43/50**	**10/10**	**9/10**	**10/10**	**8/10**	**10/10**	**48/50**

Visual differences between treatments can be observed in (Figure 1(a)), which shows the initial state of the tomato seeds in all three treatments. The control group (C5), yeast group (Y5), and spirulina group (S5) (Figure 1(b)) showed clear differences in seed development after nine days of incubation.



(a)



(b)

Figure 1. (a) Seeds before germination, (b) Seeds after germination (day 9).

3.1. Germination Percentage

As shown in (Figure 2), the Spirulina group recorded the highest germination percentage at 96% (48 out of 50 seeds), followed by the yeast group at 86% (43/50 seeds), and the control group at 70% (35/50 seeds). The differences between the groups were statistically significant ($p = 0.026$).

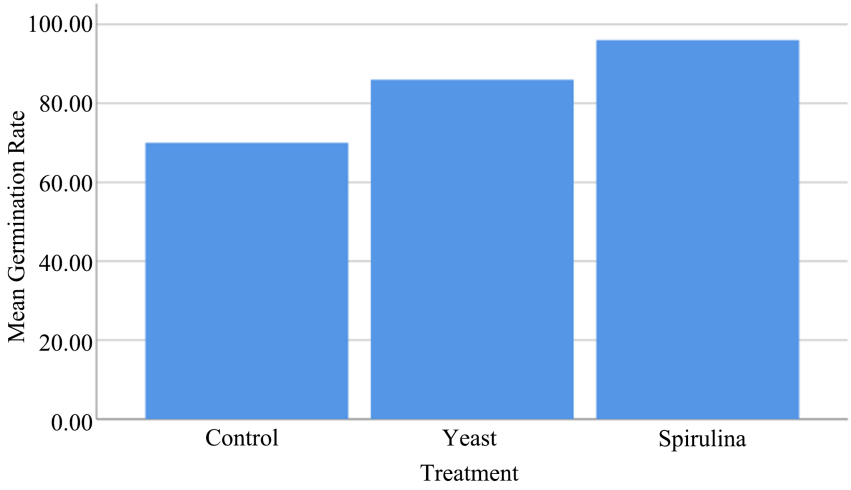


Figure 2. Spirulina had a higher germination rate than the control treatment using one way ANOVA.

3.2. Germination Speed

The Spirulina group showed the fastest germination rate (13.87), followed by the yeast group (11.81) and the control group (8.58). These differences were statistically significant (p = 0.004), as shown in (Figure 3).

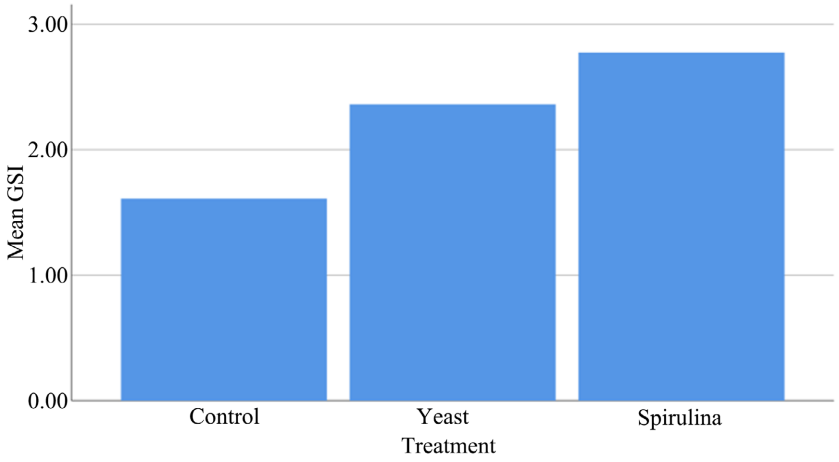


Figure 3. Using One Way ANOVA, significant differences were observed in the germination speed index between treatments.

3.3. Mean Germination Time (MGT)

The mean germination time was shortest in the Spirulina group (3.59 days), followed by the yeast (3.91 days) and control group (4.29 days), as illustrated in (Figure 4). However, this difference was not statistically significant (p = 0.072). A summary of the seed germination parameters for all treatment groups is presented in Table 2.

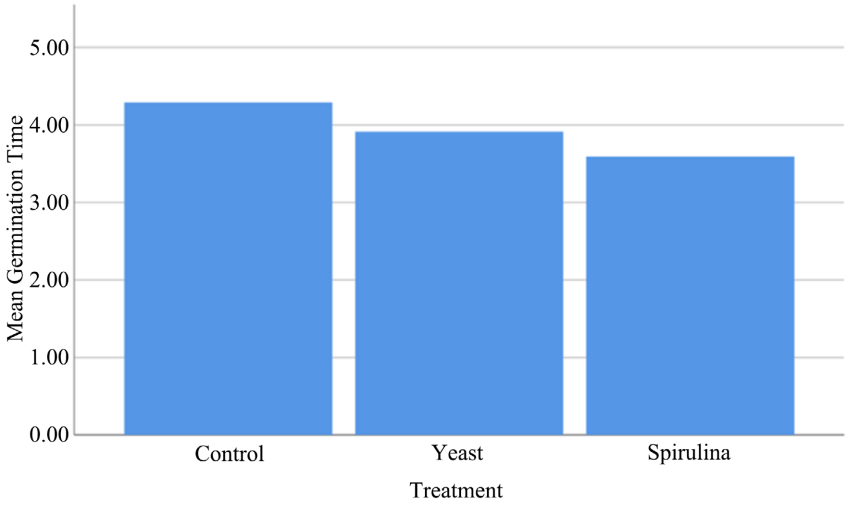


Figure 4. Spirulina recorded the shortest germination time, followed by yeast, then the control group. A One Way ANOVA, showed no significant differences.

3.4. Statistical Considerations

One-way ANOVA was used to compare the treatment groups. Statistical analysis

was conducted using SPSS. No post-hoc tests were applied due to the small sample size and exploratory nature of the study.

This table presents the daily germination count of tomato seeds in all treatment groups (control, yeast, and Spirulina) over a 9-day period. Each treatment included five plates and the number of germinated seeds was recorded daily. Spirulina-treated seeds showed faster and higher germination rates, notably in the early days, whereas the control group exhibited the slowest and least consistent germination rate.

Table 2. Seed germination parameters in tomato seeds treated with suspensions.

Parameter	Control Group	Yeast Group	Spirulina Group	p-value
Total Germinated Seeds	35	43	48	0.026
Germination Percentage (%)	70%	86%	96%	0.026
Speed of Germination	8.58	11.81	13.87	0.004
Germination Time	4.294	3.914	3.596	0.0720

Spirulina and yeast suspensions had a positive effect on total germination, percentage, speed, and germination time, whereas the control group had the least effect.

4. Discussion

The results of this experiment indicated that the suspension had a positive effect on the germination of tomato seeds, especially Spirulina Arthrospira platensis. Seeds soaked in Spirulina had the highest germination rate (96%) and highest germination rate (13.87). The shortest germination time was 3.59 days. These findings align with previous studies, given that Spirulina contains auxins, cytokinins, and extracellular polymeric substances (EPS), which enhance germination [3].

Spirulina enhances germination by improving soil water availability, nutrient uptake, and organic compound interactions, thereby creating a favorable environment for seed development [20]. The EPS produced helps retain water around the seed, supporting the rapid hydration and activation of metabolic pathways. Furthermore, these compounds enhance microbial colonization and improve soil structure, which can lead to improved oxygen availability and enzymatic activity during early seed development [3] [21].

Seeds treated with Saccharomyces cerevisiae also showed better results than the control group, with germination rates of 86% and a germination speed of 11.81%, respectively. This is attributed to the ability of yeast to produce growth regulators such as indole-3-acetic acid (IAA) and gibberellins [1] [4], which stimulate root elongation and cell division. Yeast also contributes by releasing ammonia, solubilizing phosphate, and producing siderophores and hydrolytic enzymes that enhance microbial interactions and protect seedlings from pathogens [22].

The biological mechanisms underlying the observed effects can be explained by

the physiological properties of both Spirulina and yeast. Spirulina enhances germination by stimulating hormone-regulated pathways, particularly via auxins and cytokinins, which are essential for initiating cell division and elongation of the radicle [3] [21]. It also secretes extracellular polysaccharides that aid in water retention and serve as a carbon source for beneficial microbes, improving seed–soil interactions. In contrast, yeast enhances germination by producing IAA, improving nutrient solubilization, and indirectly suppressing harmful fungi, thus creating a microbially favorable environment for germination [4] [22].

Recent findings by Parmar *et al.* [21] support the outcomes of the current study. Their review emphasized that microalgae, such as Spirulina, serve as multifunctional plant growth additives by producing phytohormones, such as auxins and gibberellins, enhancing nutrient availability, and promoting root colonization. These mechanisms are particularly valuable under abiotic stress, reinforcing the biostimulant potential of Spirulina in sustainable agriculture. These results are also consistent with those of previous studies, such as those by Chua *et al.* [3] and Xu *et al.* [20], highlighting the role of Spirulina as a biostimulant under salinity and environmental stress. The difference in performance between the Spirulina and yeast groups in this study suggests that Spirulina may be more effective under the tested conditions, although both treatments outperformed the control.

These comparisons confirm that even under non-laboratory conditions, bioagents such as Spirulina and yeast can significantly affect early plant development. Post-hoc analyses (e.g., Tukey's HSD) are recommended in future studies to validate observed differences between treatments.

Further studies under control and field conditions are required to confirm these trends.

5. Conclusion

The experiment showed that the group treated with Spirulina was more effective than the other groups, resulting in a higher germination rate and faster growth because of Spirulina's growth-enhancing characteristics. Yeast can also be used as a biofertilizer and has a positive effect on germination. However, there is still a need for further studies at different concentrations and conditions, as this study focused only on a single concentration for each treatment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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