Sweet corn seed response to FULZYME.PLUS biofertilizer treatment and its effect on germination speed and viability.

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Abstract

A laboratory experiment was conducted in the laboratories of Al-Qasim Green University / College of Agriculture, Department of Field Crops, during the autumn season of 2025 to evaluate the vitality of sweet corn seeds through, The laboratory experiment was conducted using a Completely Randomized Design (CRD) with four replicates. Seeds were treated by soaking for 24 hours in different concentrations of the biofertilizer Fulzyme (15, 25, 35, 45, and 55 g kg^{-1} seeds), in addition to a control treatment (distilled water only), with the aim of selecting the best stimulating concentration that gives the best results for the studied seed traits before planting. After the completion of the soaking period. The results showed that the Germination Speed Index was significantly superior at the concentration of 35 g kg^{-1}, which recorded the highest mean value of 9.89 seedlings day^{-1} compared with the other concentrations and the control treatment.Regarding the other studied traits, namely germination percentage, radicle length, and plumule length, no significant differences were observed between the concentrations of 35 and 45 g kg^{-1}. However, the concentration of 35 g kg^{-1} recorded the highest values, reaching 85.80% for germination percentage, 13.15 cm for radicle length, and 8.80 cm for plumule length, while the concentration of 45 g kg^{-1} produced closely similar values of 83.57% for germination percentage, 12.73 cm for radicle length, and 8.25 cm for plumule length.In contrast, the control treatment (seeds soaked in distilled water only) recorded the lowest mean values for all studied traits, reaching 5.85 seedlings day^{-1} for the Germination Speed Index, 66.22% for germination percentage, 8.88 cm for radicle length, and 6.30 cm for plumule length.

Regarding the other traits, no significant differences were observed between the concentrations of 35 and 45 g kg^{-1} for the following parameters: mean germination time, seedling dry weight, and accelerated aging test. The concentration of 35 g kg^{-1} recorded values of 3.275 days, 0.328 g, and 49.91%, respectively, whereas the concentration of 45 g kg^{-1} recorded 3.075 days, 0.323 g, and 48.13%, respectively. These values were compared with the control treatment, which recorded the lowest means for all the aforementioned traits, reaching 5.075 days, 0.188 g, and 38.12%, respectively.For the Seedling Vigor Index, the concentration of 35 g kg^{-1} significantly outperformed the other concentrations, recording a value of 1882.5 compared with the control treatment, which recorded the lowest mean value of 1005.0.In conclusion, seed treatment with the biofertilizer (FULZYME.PLUS) improved germination uniformity and reduced the time required for the formation of normal seedlings per unit area.

Keywords: Sweet corn (Zea mays L.), FULZYME.PLUS, Seed soaking, Seed viability.

1:Introduction

Sweet corn (Zea mays L. var. saccharata) ranks fourth in the Arab world after wheat, rice, and barley in terms of cultivated area, and third after wheat and barley in terms of production. In Iraq, the cultivated area of sweet corn reached 515,160 dunums, while the total production amounted to 405,427 tons, with an average yield of 1034.3 kg

dunum^{-1} Biofertilizer is considered a biological intervention aimed at stimulating plant growth and improving soil fertility through the use of microorganisms or biological formulations, instead of relying entirely on chemical fertilizers. [1].

Sweet corn is also considered an important crop in modern agriculture, as it is consumed directly as a vegetable due to the high sugar content of its kernels compared with field corn, which gives it a distinctive nutritional and marketing advantage [2].

The term seed vigor refers to the ability of seeds to germinate rapidly and uniformly and to produce vigorous seedlings capable of tolerating various environmental conditions. It differs from germination in that seed lots with acceptable germination percentages may still fail to produce vigorous or productive plants if their vigor is low. Since sweet corn seeds often face challenges during germination and crop establishment due to environmental conditions or inherent seed characteristics, improving seed vigor can significantly contribute to enhancing field productivity [3].

2:Material and Methods

2-1: Laboratory Experiment

The laboratory experiment was conducted using a Completely Randomized Design (CRD) with four replicates to evaluate the effect of seed treatment through soaking for 24 hours in different concentrations of the biofertilizer FULZYME.PLUS. The origin of JH Biotech, Inc., the producer of the biofertilizer FULZYME.PLUS, is the United States of America. The fertilizer The biofertilizer FULZYME.PLUS represents a biological intervention aimed at stimulating plant growth and improving soil fertility through the use of beneficial microorganisms or biological formulations rather than relying entirely on chemical fertilizers. Scientifically, microorganisms such as Plant Growth-Promoting Rhizobacteria (PGPR) or associated fungi present in this biofertilizer play an important role in nitrogen fixation, phosphorus solubilization, and the production of plant hormones that stimulate root growth and enhance nutrient uptake. These microorganisms also contribute to improving crop productivity and tolerance to environmental stresses through mechanisms such as N_2 fixation, P/K solubilization, and phytohormone production. Therefore, the use of biofertilizers in seed treatment of crops such as sweet corn represents a promising approach for improving seedling establishment and post-germination performance [4].

Study Objective: To determine the best treatment among the FULZYME.PLUS biofertilizer seed-soaking treatments that accelerates germination and emergence and produces high-quality seeds.

consists of beneficial bacteria Bacillus subtilis , Pseudomonas putida and bioenzymes such as protease, amylase, and lipase. The soil was compatible with the recommended guidelines. The tested concentrations were 15, 25, 35, 45, and 55 g kg^{-1} seeds, in addition to a control treatment (distilled water only). The aim was to determine the most effective stimulating concentration that could provide the best results for the studied seed traits prior to planting.

After the completion of the priming period, all tools used in the laboratory germination test were sterilized using sodium chloride solution and alcohol to prevent fungal and bacterial contamination. Subsequently, sweet yellow maize seeds were germinated using 200 seeds distributed over four replicates following the roll towel method, where seeds were placed on moistened blotting paper previously wetted with distilled water, then covered and placed in a germinator at a temperature of 25 ± 2 °C for ten days.

After the incubation period, measurements of the studied seed traits were recorded. Based on the obtained laboratory results, the most effective concentrations of FULZYME.PLUS selected for the field experiment were 25, 35, and 45 g kg^{-1}, in addition to the control treatment.

2-2-1: Traits Studied in the Laboratory Experiment

2-2-1-1: Germination Speed Index (seedlings day^{-1})

The number of normal seedlings was counted daily starting from the first day (24 hours after placing the seeds in the germinator) until the final day of the test period (10 days). The Germination Speed Index (GSI) was calculated according to [5] .

2-2-1-2: Laboratory Germination Percentage (%)

The number of normal seedlings was counted on the fourth day after placing the seeds in the germinator. The results were then converted to percentage according to [6] .

2-2-1-3: Mean Germination Time (days)

Mean Germination Time (MGT) was calculated according to [7] .

2-2-1-4: Radicle and Plumule Length (cm)

Ten normal seedlings were randomly selected after the completion of the germination test period (10 days). The plumule was separated at its point of attachment to the mesocotyl, while the radicle was separated at its point of attachment to the seed. The lengths of the radicle and plumule were measured separately using a ruler, and the average length for each was calculated [8].

2-2-1-5: Seedling Dry Weight (mg)

The same normal seedlings used for measuring radicle and plumule length were used to determine seedling dry weight. Both the radicle and plumule were separated from the seed at their point of attachment and placed in perforated paper bags. The samples were then dried in an electric oven at 68 °C for 48 hours, after which their weight was measured using a sensitive balance with four decimal places. The mean dry weight of the seedling was calculated by dividing the total weight by the number of seedlings [9].

2-2-1-6: Seedling Vigor Index

The Seedling Vigor Index (SVI) was calculated using the equation described by [8].

2-2-1-7: Accelerated Aging Test (AAT)

A seed sample from each treatment was placed on a wire mesh inside a small plastic box containing 40 ml of distilled water, ensuring that the seeds did not come into direct contact with the water. The

container was then loosely sealed and placed in a germinator at 43 ± 1 °C for 72 hours with 100% relative humidity according to [9].

After the aging treatment, the seeds were subjected to the standard germination test, and the number of normal seedlings was counted after 7 days under standard germination conditions. The results were then converted to percentage.

2-3: Statistical Analysis

The data of the field experiment were statistically analyzed using analysis of variance (ANOVA) under the Randomized Complete Block Design (RCBD). The data of the first and second laboratory experiments were also analyzed using the Completely Randomized Design (CRD) to evaluate seed vigor and viability according to factorial experiments, using the Genstat program. The significance of differences between means was tested using the Least Significant Difference (LSD) at the 5% probability level for each source of variation [10].

3:Results and Discussion

3-1: Effect of Seed Treatment with Different Concentrations of FULZYME.PLUS Fertilizer on Some Seed Vigor Tests (Germination Speed Index, Germination Percentage, Radicle Length, and Plumule Length)

The results of the analysis of variance presented in Table (1) indicate the presence of significant differences among the different treatments of soaking maize seeds in FULZYME.PLUS concentrations (15, 25, 35, 45, and 55 g kg^{-1}) compared with the control treatment (seeds soaked in distilled water only) for the studied traits. The Germination Speed Index (GSI) showed a significant superiority at the concentration of 35 g kg^{-1}, which recorded the highest mean value of 9.89 seedlings day^{-1} compared with the other concentrations and the control treatment.

Regarding the other traits, namely germination percentage, radicle length, and plumule length, no significant differences were observed between the concentrations of 35 and 45 g kg^{-1}. However, the concentration of 35 g kg^{-1} recorded the highest values, reaching 85.80% for germination percentage, 13.15 cm for radicle length, and 8.80 cm for plumule length, whereas the concentration of 45 g kg^{-1} produced closely similar values of 83.57% for germination percentage, 12.73 cm for radicle length, and 8.25 cm for plumule length.

In contrast, the control treatment (seeds soaked in distilled water only) recorded the lowest mean values for all studied traits, reaching 5.85 seedlings day^{-1} for the Germination Speed Index, 66.22% for germination percentage, 8.88 cm for radicle length, and 6.30 cm for plumule length.

The superiority of the soaking treatment with the 35 g kg^{-1} concentration of FULZYME.PLUS in terms of Germination Speed Index and most early seedling growth traits may be attributed to the fact that this concentration represents the optimum level that achieves a suitable balance in stimulating physiological and enzymatic processes within the seeds during germination. Biofertilizers such as FULZYME.PLUS often contain beneficial microorganisms and growth-promoting compounds that enhance metabolic activity within the seed. When seeds are soaked at this concentration, the rate of water

absorption (imbibition) increases, which represents the first essential step in initiating germination, leading to the reactivation of enzymatic systems within the embryo.

The absence of significant differences between the concentrations 35 and 45 g kg^{-1} in germination percentage, radicle length, and plumule length may indicate that both concentrations fall within the effective range for stimulating physiological processes in seeds. At this level, the seed may reach nearly its maximum physiological response, resulting in limited and statistically non-significant differences between them [11].

These results are consistent with several studies that used plant growth regulators through seed soaking methods. For instance, [12]reported that soaking maize seeds in salicylic acid significantly increased germination percentage as well as radicle and plumule length due to the stimulation of metabolic and enzymatic activities within the seed. This improvement is attributed to the role of growth regulators in accelerating water uptake and activating enzymes responsible for the mobilization of stored seed reserves such as carbohydrates and proteins. Consequently, more energy becomes available for embryo growth, cell division, and elongation, which positively affects germination speed and seedling growth.

The reduction observed in the studied traits at the higher concentration 55 g kg^{-1} may be attributed to the fact that exceeding the optimal concentration could lead to partial inhibitory effects on biological processes or disturbances in metabolic balance within the seed. Such effects may limit the ability of cells to divide and elongate with the same efficiency observed at the intermediate concentration (35 g kg^{-1}). Therefore, this concentration appears to be the most suitable level for stimulating plant growth for the studied traits [12].

Table 1. Effect of seed treatment with different concentrations of FULZYME.PLUS fertilizer on seed vigor.

Soaking Concentrations	Measured Traits			
	Germination Speed Index (seedlings/day)	Germination Percentage (%)	Radicle Length (cm)	Plumule Length (cm)
0	5.85	66.22	8.88	6.30
15	6.83	73.10	10.73	6.70
25	7.35	74.20	11.95	6.83
35	9.89	85.80	13.15	8.80
45	8.08	83.57	12.73	8.25
55	7.17	71.65	9.78	6.40
LSD	0.970	4.036	0.863	0.775

3-2: Effect of Seed Treatment with Different Concentrations of FULZYME.PLUS Fertilizer on Some Seed Vigor Tests (Mean Germination Time, Seedling Dry Weight, Seedling Vigor Index, and Accelerated Aging Test)

No significant differences were observed between the 35 and 45 g kg^{-1} concentrations, with 35 g kg^{-1} recording 3.275 days and 45 g kg^{-1} 3.075 days, while the control treatment showed the highest value of 5.075 days. This indicates that both concentrations fall within the effective physiological range for stimulating metabolic processes within the seed, such as increased water uptake and activation of enzymatic systems responsible for mobilizing stored reserves like starch, proteins, and lipids, which accelerates germination and reduces MGT compared to the control [13,14].

The 35 g kg^{-1} concentration recorded a dry weight of 0.328 g, 45 g kg^{-1} recorded 0.323 g, while the control was 0.188 g. The improvement in seedling dry weight is due to enhanced metabolic and enzymatic activity induced by the biofertilizer, which releases energy from stored seed reserves, supporting better root and shoot growth and increasing the dry mass of seedlings[15].

No significant differences were observed between 35 and 45 g kg^{-1}, with values of 49.91% and 48.13%, respectively, while the control recorded 38.12%. Increased stress tolerance is attributed to enhanced enzymatic activity, higher ATP production, and improved respiration within the seed, which boosts its ability to withstand stress conditions simulated by the accelerated aging test, resulting in higher germination after treatment [12].

The 35 g kg^{-1} concentration recorded the highest SVI (1882.5), while the control showed the lowest value (1005.0). SVI depends on both germination percentage and seedling length; thus, improvement in these traits at 35 g kg^{-1} leads to higher SVI values. Growth-promoting bacteria contribute to the secretion of phytohormones such as auxins and gibberellins and enhance nutrient uptake, which increases seedling vigor and strength [15,16].

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Table (2): Effect of seed treatment with different concentrations of FULZYME.PLUS fertilizer on seed vigor.

Soaking Concentrations	Measured Traits			
	Mean Germination Time (days)	Seedling Dry Weight (g)	Seedling Vigor Index	Accelerated Aging Test (AAT)
0	5.075	0.188	1005.0	38.12
15	4.400	0.280	1182.5	44.05
25	3.825	0.318	1412.6	47.86
35	3.275	0.328	1882.5	49.91
45	3.075	0.323	1753.8	48.13
55	4.750	0.200	1246.2	44.67
LSD	0.624	0.162	47.83	4.2

4:Conclusion

1. The study results revealed significant differences between the treatments of seed soaking with the biofertilizer and the control treatment for all studied physiological traits, indicating the positive role of the biofertilizer in enhancing seed vigor and germination characteristics.
2. Seed treatment with FULZYME.PLUS significantly improved seed vigor indicators, including the Accelerated Aging Test (AAT), Germination Speed Index (GSI), Mean Germination Time (MGT), and Seedling Vigor Index (SVI) compared with untreated seeds.
3. The concentration of 35 g kg^{-1} significantly outperformed the other concentrations for most studied traits, recording the highest values for AAT, GSI, and SVI, as well as reducing MGT.

5: Recommendations

1. It is recommended to use the biofertilizer FULZYME.PLUS at concentrations of 35 and 45 g kg^{-1} seeds for soaking sweet corn seeds for 24 hours before sowing, due to its high efficiency in improving seed vigor and germination traits.
2. Adopting the technique of seed soaking with biofertilizers is suggested as a modern agricultural practice that contributes to enhanced seedling growth and germination efficiency, especially for important field crops such as maize.

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