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Developing A Nano-Fertilizer of Iron Oxide NPs Using Yeast Extract and Studying its Effectiveness on the Growth and Germination of *Nigella sativa* Seeds

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Abstract: The use of nanofertilizers has increased dramatically in the last several years. Environmentally sustainable Fe_2O_3-nano-fertilizers are important for improving agricultural yields and physics. However, overuse of chemical nanofertilizers can have negative effects on both human health and the environment. Soil and plants are the most vital natural resources for human life and development, and both collect high concentrations of residues from nano-fertilizers. Numerous techniques have been proposed for producing nano fertilizers aimed at enhancing the germination rate, wetness, length, power, and dry weight of seedlings. A fresh study on the effects of hydrothermally prepared nano fertilizers made from *yeast* extract on the development and germination of *Nigella sativa seeds*. Fe_2O_3-Nano particles were produced with an average crystallite size of 12–39 nm, as shown by XRD. The FE-SEM-Pictures of Fe_2O_3-NPs display the morphologies of Nanostructures or Nano tapes. Fe_2O_3-NPs' optical properties reveal an absorbance band and an energy bandgap with maximal absorbance peaks at 231 nm and optical energy gaps of 3,8 eV, respectively. The outcome the impact of nano fertilizers (Fe_2O_3) on the development and germination of *Nigella sativa seeds* has been investigated through this activity. The study's treatments had a significant impact on the germination period; For example, when soaked in a suspension of baking *yeast* at a concentration of 1 g L^{-1}, the germination period dropped to 14.71 days from 18.10 days for the control treatment. Less soaked in 1 mg L^{-1} of Nano *Bread Yeast* Extract, the Germination Duration was 14.16 days.

Keywords: Fe_2O_3 NPs; Hydrothermal method; Nano-fertilizer; *Nigella sativa seeds*; *Yeast extract*.

Introduction

Natural substances are now a potent alternative for researchers creating novel therapeutic medications for a variety of illnesses. As a fascinating interdisciplinary field that makes substantial use of materials at the nanoscale, nanotechnology is currently playing a critical role in presenting new application potentials in a range of areas, including physics, chemistry, biotechnology, and medicine (Barabadi *et al.,* 2019; Barabadi, *et al.,* 2019; Varadharaj, *et al.,* 2020; Lazim, & Ramadhan, 2020). Proteins, enzymes, sulfur compounds, alkaloids, flavonoids, all amino acids, peptides, vitamins, and minerals are among the many phenolic components found in yeast extracts. Because proteins are present in these *plant* extracts, they have a high concentration of quercetin and fructose, which can decrease ions to NPs. Initially, the *bread-yeast*-microorganisms were purchased at a market in Baghdad, Iraq. Table 1 is a list of the species (*yeast*) kinds, families, and types applied to the biosynthesis of NPs (Jach *et al.,* 2022). The growing need to develop environmentally acceptable technologies for material synthesis has brought nanoparticles (NPs) a great deal of attention. In domains related to science and technology, including engineering, they have grown in significance (Ramadhan *et al.,* 2019; Abdullah *et al*.,2025). Fe_2O_3 NPs alluring physico-chemical properties have also made them more and more appealing to researchers looking into antibacterial, antifungal, anticancer, and plant-growth applications (Abid *et al.,* 2021). Since Fungi-based NPs are more stable and economical than those derived from microbes, and their biological production holds potential benefits (Karpagavinayagam *et al.,* 2019). Fe_2O_3 NPs controllable size, strong magnetism, and low toxicity make them an important source of nanofertilizers (Elbasuney *et al.,* 2022). The activity of NPs depends on the strain of the leaf, since plant cell walls differ from one another. Its mechanism is the electrostatic contact of (NPs) with the *plant* cell wall, leading to the degradation of the plant wall and the induction of harmful oxidative stress using of the production of reactive oxygen species via photocatalytic activity (Malhotra & Alghuthaymi*.,* 2022).

Table (1): A List of *species* (*yeast*) used for the bio-synthesis of Fe_2O_3 NPs (Abid& Kadhim ,2022)

Plant Species	**Common Name**	**Family**	**Type**	**Chemical formula**
Yeast	Saccharomyces cerevisiae	Brewer's	grain	C85H124N14O16S

Green manufacturing of metallic IO-NPs (Fe_2O_3), has been a novel and exciting area of research in recent years. Green synthesis of IO-NPs has gained popularity recently (Rihab *et al.*, 2018; Al-Hatem *et al.,* 2019) because it is simple, cheap, creates very stable nanoparticles, takes less time, produces non-toxic byproducts, is safe for the environment, and can be easily scaled up for large-scale synthesis. Because chemical synthesis techniques create harmful chemical species adsorbed on the surface of IO-NPs, green synthesis has gained popularity as a means of creating diverse metal and metal oxide nanoparticles. It has been shown that producing these IO-NPs using green synthesis methods is more reliable and cost-effective (El-Saadony *et al.,* 2021; Jahangirian *et al.,* 2020; Kadhim *et al.,* 2022). Rumination speed of seedlings in different ways. The production of environmentally friendly nano fertilizers (Fe_2O_3) by hydrothermally combining $FeCl_3$ and *yeast* extract can aid in the development of *plant* growth. However, to examine the structure and optical characteristics, nano fertilizers (Fe_2O_3) were evaluated using XRD, FESEM, and UV-visible. Ensuring that the development and application of nano fertilizers are informed by ethical and social factors, as well as their accessibility and utility for all parties involved–including local populations and small-scale farmers–is imperative. The study's treatments had a significant impact on the germination period; For example, when soaked in a suspension of baking yeast at a concentration of 1 g L^{-1}, the germination period dropped to 14.71 days from 18.10 days for the control treatment. Less Soaked in 1 mg L^{-1} of Nano *Bread Yeast* Extract, the Germination Duration was 14.16 days, as opposed to 16.21 days in the control condition.

Materials & Methods

Diese research was conducted at the local market and the biology-department lab of the University of Mosul's College of Education for Girls. "The local variety and a reliable source were used to make the *seeds*". The two variables and three replications in the trials were planned using a fully randomized design (CRD). At a concentration of (0, 1, 2) g L^{-1}, dry suspended *bread yeast* was soaked in the first factor, and at a concentration of (0, 1, 2) mg L^{-1}, nano-bread-*yeast*-extract was soaked in the second factor. A total of 27 experimental units (3 x 3 x 3) were used. The transactions for the study were constructed as follows:

1. Germination period (day). "Represented by the number of days required for *seed germination*, as *germinated seeds* were counted every day, starting from the fourth day after planting, when the first sign appeared, until germination stopped completely on the twenty-fifth day after planting".

2. The percentage of germination. This was done using the following equation: According to (ISTA, 2001).

$$\text{Germination\%} = \frac{\text{number of germinated seeds}}{\text{total number of seeds}} \text{x}100\%$$

3. Seed germination speed (day). This was calculated using the following equation: -

$$\text{"Germination speed"} = \frac{\text{"total (number of seeds germinating each day x number of the day) number of germinated seeds"}}{\text{"The number of germinated seeds at the end of the germination period"}}$$

4. Homogeneity of germination (seed day^{-1}). It is one of the important characteristics of the growth of plants. The more homogeneous seedlings in their growth (that is, they sprouted almost at the same time), are the same in length, thickness, and strength of growth, and they are all ready for growing in the permanent field without remaining of them seedlings not suitable for planting on time. According to the homogeneity of germination, according to the following Equation:

$$\text{Homogeneity of germination} = \frac{\text{"Number of total seeds germinated at the end of the germination period"}}{\text{" Number of days from the beginning of seed planting to the cessation of germination"}}$$

The interaction between Nano fertilizers (Fe_2O_3 NPs) and *bread Yeast*

Because of the negative charge on their surface, metal complexes can pass through yeast cells' membranes and allow negatively charged molecules to pass through. Root elongation is aided by IO nanofertilizers (Fe_2O_3 NPs), according to research on the subject. *Plant* growth was accelerated, nevertheless, when *yeast* extract was added to IO. They contend that vitamin and protein intake promote root elongation. Fe_2O_3 NPs surface characteristics have a significant role in influencing plant development. Conversely, seed treatments containing 0.45–3% IO-(Fe_2O_3) NPs improved the physiological attributes of *Nigella sativa* grown in sunlight, as evidenced by an increase in the seeds' germination rate and activity indices. Also, the impact of ribulose-phosphate-carboxylase/oxygenase, plant dry weight, photosynthetic rate, and chlorophyll was all significant (Abd El-Hack *et al.,* 2021).

Preparation of (*Yeast*) Extract

Diese Investigation employed fresh ingredients (*yeast*): 100 mL of "distilled water" with 5.5383 g of powder in it, heated at 80ºC for 90 minutes. Allow the mixture to cool to room temperature for 10 minutes after that. The solution was thereafter immersed in an ice bath, to ensure uniformity. We next ran it through Whatman No. 4 Filter Paper, which has a Pore size of 20 m, to remove any remaining dirt particles. After that, the mixture was centrifuged for "15 minutes" at "3000 rpm" in order to remove any remaining particles. Shortly after being filtered, the *plant* extracts were employed in the environmentally friendly manufacture of NPs (Abid *et al.,* 2022; Abid, 2020; Almayyahi, & Al-Atab, 2024) Figure 1 provides instructions for turning a raw material into an extract.

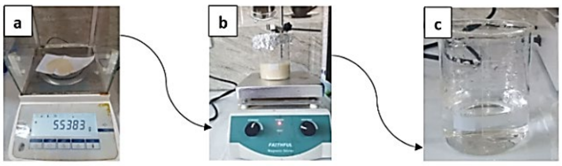

Fig. (1): (a-b) Steps of converting fresh bread *yeast* powder into *yeast* extract.

Green Synthesis of Nano fertilizer (Fe_2O_3) NPs Via Hydrothermal Method

Initially, several tests have been carried out to determine the ideal setup parameters for the experimental section. Following the addition of 100 mL of the *yeast* extract to 50 mL of a 1 M, 16 g $FeCl_3$ solution, the mixture was stirred with a magnetic stirrer for 90 minutes at 70–80 °C. The mixture was well mixed before being placed in a 100 mL Teflon-Autoclave and cooked at 100 °C for 15 hours. The autoclave then came to normal temperature. After filtering and repeatedly cleaning with distilled water and acetone, the gray deposits were placed in an oven set to 300°C for three hours to dry. Figure 2 shows the procedures for making Fe_2O_3 NPs with yeast grain extract.

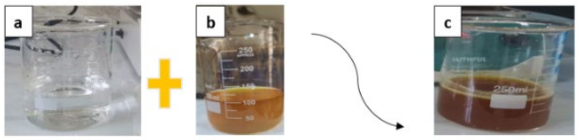

Fig. (2): The stages of preparation of Nano fertilizer (Fe_2O_3) NPs using *yeast* extract (a) *yeast* extarct, "b) Ferric ($FeCl_3$) c solution, (c) Fe_2O_3 NPs.

Preparing a suspension of dry *bread yeast*

In order to activate dry baker's suspended *bread yeast*, dissolve (0, 1, 2) grams of dry *baker's yeast* in one liter of warm distilled water at 32°C, then stir in one gram of sugar (sucrose). produced by *yeast* in accordance with (Al-Hatem *et al.,* 2018; Abbas, 2023).

Prepare Nano *bread yeast* extract solution)

"The preparation was prepared with a weight of (0, 1, 2) mg L^{-1} of *Nano Bread Yeast* Extract and dissolved in 1 Liter of distilled water". *Seeds* were immersed for 24 hours in each concentration of the treatment under study, after which they were moved to Petri dishes with filter paper that had been soaked with distilled water. Three duplicates of each treatment were then added to each of the 100 seedlings. The comparison treatment included treatment with distilled water only. "The data continued to be recorded daily until Germination ceased in all transactions".

The Involved Mechanism in Green Synthesis of Fe_2O_3 NPs from *yeast* extract

Numerous research employing a range of mechanistic techniques have examined the hidden mechanism behind the green synthesis of IO-NPs, which occurs "inside the live plants and within the sun-dried biomass" The resulting IO-NPs contribute to the early process by reducing metal ions with reducing agents or enzymes linked to cell walls (Jameel *et al.,* 2022). The ionization, that takes place when plant extract is added to a solution of chloride metals during the production of IO-NPs, is as follows:

$FeCl_3$ (aq) + Plant Extract ($C_{85}H_{124}N_{14}O_{16}S$) $\rightarrow$IONPs+H_2O (aq)+$Cl_3Fe_2O_3$

Plant proteins function as "electron donors", whereas metal ions function as "electron acceptors". Chlorophyll pigments act as molecules-level stabilizers between the donor and the acceptor. In the process of turning metal ions into metal, these biomolecules play a crucial role as a capping agent (Panwar *et al.,* 2023) Reduced cofactors or lower biosynthetic outputs seem to be the main contributors in the formation of NPs. Glycolysis produces the coenzyme NAD ("Nicotinamide adenine dinucleotide"), which is found in all cells. It's probable that NAD, an oxidizing agent that reduced itself by grabbing electrons from other molecules, transformed metal-ions into metal-NPs. Plants have an intricate network of antioxidant enzymes and metabolites to guard against oxidative damage to cell components (Ben Ayed *et al.,* 2018).

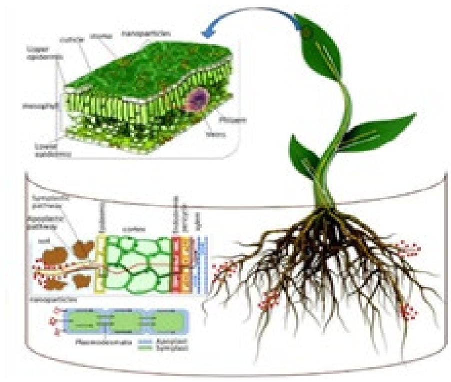

Fig. (3): Show the mechanism interaction between Nano fertilizers (Fe_2O_3 NPs) and *yeast*.

Characterizations of nano fertilizer (Fe_2O_3) NPs using *yeast* extract

A highly helpful method for finding out about a substance's crystal structure is XRD. (XRD) provides information on the orientation, lattice parameters, and crystalline phase of materials. The orientation of Fe_2O_3-generated materials in XRD6000 Shimadzu, Company/Japan was investigated using X-ray diffraction (XRD) research in order to create monochromatic Cuk-X-ray radiation. With a 10° to 40° angle of incidence, the 2θ-mode-incident-beam was powered by a 40 kV filament voltage and 30 mA current. With the use of a device called a FESEM, one may acquire high-magnification pictures of any surface as well as two-dimensional images that highlight the surface's structural topography and allow one to see even the smallest topographic features. Tuscan Mira3 FESEM-Czechia in Mashhad, Iran, has evaluated the samples (Upadhyay & Bano, 2023). To determine a material's optical characteristics, "UV-visible spectroscopy" measures a substance's "absorbance or transmittance" in solution or solid form. A "UV-vis spectrophotometer (Double Beam Li-2800) and a T60, London, armed with a deuterium-and tungsten lamp with a wavelength of 200-900 nm" were used to record the optical absorbance and transmittance spectra of materials that were hydrothermally synthesized using plant extracts in experiments. These monochromators have high "resolving power and photometric efficiency" in the visible and ultraviolet spectrums in a single beam. Light from deuterium lamps is directed via a filter, focused onto a grating, and finally passes through an exit slit to the material under study and finally falls onto a detector (Kingslin *et al.,* 2023). You may learn about the optimal experimental conditions and the optical characteristics of the materials by taking these readings.

Results & Discussion

XRD of nano fertilizer (Fe_2O_3) preparation from *yeast* extract

The XRD patterns of Fe_2O_3 NPs produced using yeast extract are shown in Figure 4. The diffraction peaks of the generated Fe_2O_3 NPs were observed at (-211), (220), (202), (411), (420), (003), (231), (240), and (432). These peaks were similar to each Bragg reflection. These diffraction peaks indicate a face center cubic (F.C.C.) shape that corresponds to Fe_2O_3 (hematite) NPs, based on standard JPCDS-00-016-0653 data (Taghavi Fardood *et al.,* 2019) The crystallite sizes of Fe_2O_3-nano fertilizers (NPs) derived from yeast extract ranges from 28 to 69 nm. We discover that the accuracy and intensity of the crystallization are influenced by the kind of fresh bread extract (Nusseif *et al.,* 2022; Shanwaz *et al.,* 2023). Table 2 displays the findings of the crystallite size estimation process for Fe_2O_3 NPs using yeast extract. The crystallite size (D) was established using Scherrer's formula (Ben Ayed *et al.,* 2018; Lassoued *et al.,* 2019). That is 0.15418 nm (Cu) in wavelength. (Cu K), the shape factor is k, the full width at half maximum (FWHM), and the diffraction angle is (Ben Soltan *et al.,* 2017).

$$D(nm) = (k.\lambda)/\beta\cos\theta$$

Where k is the form factor (0.9), is the full width at half maximum (FWHM), is the wavelength (0.15418 nm, Cu K), and is the diffraction angle.

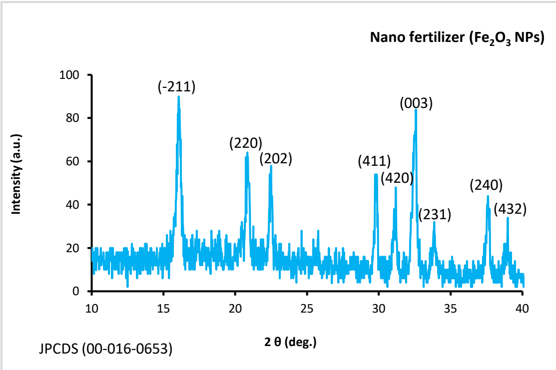

Fig. (4): XRD patterns of Fe_2O_3 NPs as-prepared by a hydrothermal method using *yeast* extract at 300°C.

Table (2): XRD measurements of Fe_2O_3 NPs created via a hydrothermal way from *yeast* extract at 300°C.

Plant extract	Phase	2 θ (deg.)	FWHM	(hkl)	D (nm)
yeast	Fe_2O_3	15.68	0.100	(-211)	39.06586
		20.66	0.176	(220)	28.59094
		22.34	0.233	(202)	39.35968
		29.10	0.209	(411)	28.75205
		31.20	0.287	(420)	69.52334
		32.20	0.209	(003)	33.43199
		33.40	0.287	(231)	28.97553
		37.30	0.120	(240)	46.14112
		39.20	0.251	(432)	33.34308

FESEM analysis of nano fertilizer (Fe_2O_3) preparation from *yeast* extract

The morphological structure of the reaction products during the production of metal nanoparticles was ascertained using the FE-SEM analysis. The hydrothermal technique employing yeast grain extract was used to determine the nano-tape-like structure of Fe_2O_3 NPs at 300ºC. The particle size and shape are 20 to 50 nm, as seen in Figures (5) (a-b) and Table (3). Higher temperatures might be the cause of this finding. Moreover, longer reaction times will cause the crystallization to expand into smaller particles, providing the "nucleation" and "growth processes" of tiny particles from Fe_2O_3 nuclei. Because Fe_2O_3 is more crystalline, plants have an impact on the production of Fe_2O_3-nanostructures. Particle sizes produced by "Scherrer's formula" are smaller than those predicted from FE-SEM pictures (Taghavi Fardood *et al.,* 2019; Malhotra & Alghuthaymi, 2022).

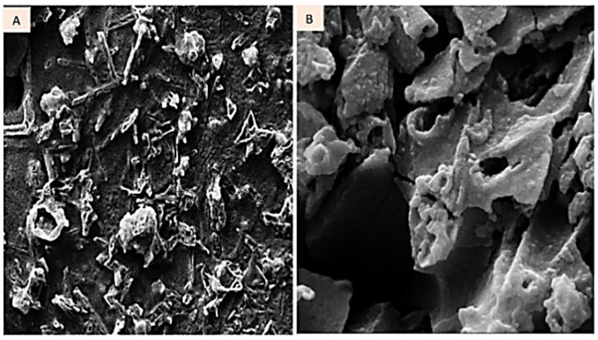

Fig. (5): FESEM analysis of Fe_2O_3 NPs produced via a hydrothermal method using *yeast* extract at 300ºC.

Table (3): FESEM measurements of Fe_2O_3 NPs created via a hydrothermal way from yeast extract at 300ºC.

Plant extract	**Phase**	**morphology**	**particle size**
yeast	Fe_2O_3	taps	20-50

UV-visible spectra of nano-fertilizer of iron oxide NPs using *yeast* extract

Special characteristics in the absorption area of the spectrum can be explained using UV-Vis-Spectrophotometers. Because of the variations in material thickness, which cause absorbance to rise with thickness, it is evident that all of the films exhibit a range of absorbance. All films show an increase in absorbance at wavelengths shorter than 235 nm, due to the high absorbance of the films in this region. Dieses are in line with the UV-visible optical properties of Fe_2O_3-Metal. Figure 6 shows the optical absorbance spectra of the Fe_2O_3 NPs, which were produced using a hydrothermal method and yeast extract. The high absorbance percentage (235) nm seen in these results illustrates the substantial absorbance of Fe_2O_3 in this area in the spectral range of 200-900 nm (Muzafar *et al.,* 2022).

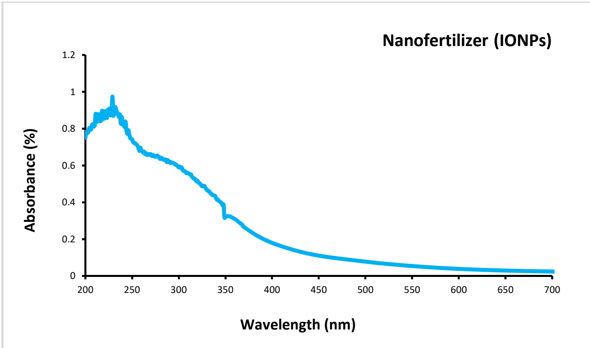

Fig. (6): UV-visible spectrum of Fe_2O_3 NPs synthesized via a hydrothermal way applied *yeast* extract at 300ºC.

By comparing the "square of the photon energy" (αhυ)2 with the photon energy (hυ), we were able to calculate the energy band gap of the Fe_2O_3 NPs produced using yeast extract. The length of the energy gap is found by extending the straight line to (αhυ)2. The energy band gap (Eg) of a film depends on its crystal structure, atomic configuration, and lattice distribution. The band gap fluctuated, as the temperature did. At a different temperature (300ºC), the formation of nanosized particles increase in the optical band gap of Fe_2O_3 NPs (Abid *et al.,* 2022; Raouf *et al.,* 2018). The XRD measurements of "average crystallite size, dislocation density, and microstrain" may explain the observed change in the optical band gap. Fig. (7) illustrates how the optical band gap of (Fe_2O_3) NPs varies based on the working temperature, starting at (2,8) eV.

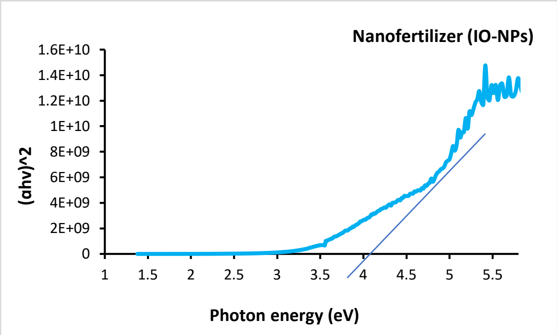

Fig. (7): Energy band gap of Fe_2O_3 NPs as-prepared by a hydrothermal method using the *yeast* extract at 300°C.

Effectiveness on the growth and germination of *Nigella sativa seeds nano-fertilizer of iron oxide NPs using yeast extract*

Table 4 Results show that the treatments under investigation had a significant impact on the germination period. Specifically, when soaked with a suspension of baking yeast at a concentration of 1 g L^{-1}, the germination period decreased and was recorded at 14.71 days as opposed to 18.10 days for the control treatment. Additionally, less Soaked in 1 mg L^{-1} of Nano *Bread Yeast* Extract, the germination duration was 14.16 days, as opposed to 16.21 days in the control condition. The results of the two-way interaction revealed that there were notable variations among the treatments; The biggest variations happened when the seeds were submerged in a suspension of baking yeast at a concentration of 2 g L^{-1} and a Nano-bread-yeast (Fe_2O_3) extract that reached 1 mg L^{-1}, recording 12.33 days, while the control treatment recorded the lowest significant values of 18.10. Employing Duncan's multiple-range-test with P=0.05, each indicates that in a row for einen or interaction variables that include different characters are clearly different.

The data presented in Table (5) indicate that are soaking the *seeds* with a baking-yeast-suspension did not lead to a significant increase in the germination rate, but it was noted that it increased significantly when soaking with a nano-baking-*yeast*-extract at a concentration of 1 mg L^{-1}, where the most important values for the most important seedlings were recorded as 95.19% versus 93.22% for control-seedlings. The results of the binary interaction indicated that the best significant value was obtained when the black seed seeds were soaked in a baking yeast suspension at a concentration of 2 g L^{-1} and treated with nano-*bread-yeast* extract 1 mg L^{-1}, as it amounted to 96.12%, while the control treatment recorded the lowest significant value, amounting to 92.0%.

"The use of the multiple-range-test, conducted by Duncan with P=0.05, all of the in row for one or interactions parameters that include different symbols are different". From the results of Table (6), it is noted that soaking with a *dry yeast* suspension at a concentration of 2 g L^{-1} caused an increase in *germination speed*, reaching 5.39 days/seed, compared to the control treatment, which was 5.84 days/seed. The seeds soaked with *yeast* nano extract at a concentration of 2 mg L^{-1} were characterized by recording the best germination speed of 5.34 days $seed^{-1}$ compared to 6.05 days $seed^{-1}$ for the control treatment. From the interaction of treatments, the best germination speed was when treated with yeast suspension at a concentration of 1 mg L^{-1} and soaked with *yeast* nano extract at a concentration of 2 mg L^{-1}, and it reached 5.03 days $seed^{-1}$.

It is clear from Tables (4, 5, and 6) that the treatment with *nano-yeast* extract improved most of the studied characteristics, as appropriate conditions were provided for growth and germination, in addition to accelerating it, as the yeast provided the necessary elements for growth, such as iron, phosphorus, potassium, and magnesium. The *yeast* also has the enzymatic ability to decompose the sugar stored in the *seeds*. These factors increased the speed and rate of germination, and this agrees with (Barabadi *et al.,* 2019; Abid 2022; Aarthi *et al.,* 2025).

Table (4): Effect of suspended *bread yeast* and Nano bread yeast extract treatment on the germination period (day) of *Nigella sativa*.

Concentrations Suspended bread yeast g L^{-1}	Nano bread yeast extract mg L^{-1}			Suspended bread yeast effect	Stander deviation (±SD)
	0	1	2		
0	18.10 c	16.12 bc	16.11 bc	16.78 b	1.101
1	15.03 a-c	15.67 bc	15.33 a-c	15.34 ab	
2	15.50 a-c	12.33 a	14.65 ab	14.16 a	
Nano bread yeast extract effect	16.21 b	14.71 a	15.36 ab		

Table (5): Effect of suspended bread yeast and Nano bread yeast extract treatment on the germination speed (day) of *Nigella sativa*.

Concentrations Suspended bread yeast g L^{-1}	Nano bread *yeast* extract mg L^{-1}			Suspended bread *yeast* effect	Standard deviation (±SD)
	0	1	2		
0	92.0 b	96.11 a	94.67 ab	94.26 a	1.132
1	94.33 ab	93.33 ab	95 69 a	94.45 a	
2	93.33 ab	96.12 a	94.34 ab	94.60 a	
Nano bread yeast extract effect	93.22 b	95 .19 a	94.90 ab		

Table (6): Effect of suspended bread yeast and Nano bread yeast extract treatment on the germination speed (days $seed^{-1}$) of *Nigella sativa*.

Concentrations Suspended bread *yeast* g L^{-1}	Nano bread *yeast* extract mg L^{-1}			Suspended bread *yeast* effect	Standrad devation (±SD)
	0	1	2		
0	6.74 bc	5.93 c	5.49 ab	6.05 b	0.298
1	5.41 bc	5.59 ab	5.65 a-c	5.54 ab	
2	5.36 ab	5.63 a-c	5.03 a	5.34 a	
Nano bread yeast extract effect	5.84 b	5.72 ba	5.39 a		

Conclusion

The *yeast* extract included $FeCl_3$ salt, which was effectively transformed into (Fe_2O_3 NPs) using the hydrothermal technique. In the diffraction peaks, the XRD data (Fe_2O_3 NPs) indicated face-center cubic (F.C.C) structures with average crystallite sizes of 28 and 69 nm. The morphological character of the crystalline phases was confirmed by a FE-SEM analysis. The mean size of (Fe_2O_3 NPs) according to FESEM-testing is (7.2, 10.96) nm, which is consistent with negligible agglomeration. According to UV-VIS investigations, the energy gap (near band edge emission) values for Fe_2O_3-nanoparticles (NPs) ranged from 3.6 eV. X-ray diffraction revealed that Fe_2O_3-Nanoparticles with an average crystallite size of 12–39 nm were created. The optical characteristics of Fe_2O_3 NPs indicate an absorbance band and an energy band gap, with maximal absorbance peaks at 231 nm and optical energy gaps of 3.8 eV. The result of Diese Activity explored the effect of nano fertilizers (Fe_2O_3 NPs) on the growth and germination of *Nigella sativa* seeds. The treatments in the research had a substantial effect on the germination duration; For example, when soaked in a solution of baking yeast at a concentration of 1 g L^{-1}, the germination period was reduced to 14.71 days from 18.10 days for the control treatment. Less Germination time was 14.16 days when steeped in 1 mg L^{-1} nano-*bread-yeast*-extract, compared to 18.10 days for the control treatment, whereas when soaking in, the germination duration was recorded in nano-*bread-yeast*-extract at a concentration of 1 mg L^{-1} was 14.16 days, compared to 16.21 days in the control treatment (Al-Atrakchii *et al.,* 2019; Al-Hatem *et al.,* 2023).

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Contributions of authors

J.Y.A: Treating the black seed plant with yeast nanofertilizer and taking plant growth measurements.

D.A.K. & M.A.A: Preparation of nano-yeast fertilizer.

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Conflicts of interest

No found interest conflict.

Ethical approval

All ethical guidelines regarding nanofertilizer preparation and treatment of black seed plants have been implemented within the limits of health safety and care issued by national and international organizations in this report.

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تطوير سماد نانوي من جسيمات أكسيد الحديد النانوية باستخدام مستخلص الخميرة ودراسة فعاليته في نمو وإنبات بذور حبة البركة

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المستخلص: لقد زاد استخدام الأسمدة النانوية بشكل كبير في السنوات القليلة الماضية، تعتبر الأسمدة النانوية Fe_2O_3المستدامة بيئيًا مهمة لتحسين المحاصيل الزراعية ، ومع ذلك فإن الإفراط في استخدام الأسمدة النانوية الكيميائية يمكن أن يكون له آثار سلبية على صحة الإنسان والبيئة. تعد التربة والنباتات من أهم الموارد الطبيعية لحياة الإنسان وتطوره، وكلاهما يجمع تركيزات عالية من بقايا الأسمدة النانوية. تم اقتراح العديد من التقنيات لإنتاج الأسمدة النانوية التي تهدف إلى تعزيز معدل الإنبات، والرطوبة، والطول، والطاقة، والوزن الجاف للشتلات. تم دراسة جديدة عن تأثيرات الأسمدة النانوية المحضرة حرارياً والمصنوعة من مستخلص الخميرة على تطور وإنبات بذور حبة البركة، اذ تم إنتاج جسيمات Fe_2O_3 النانوية بمتوسط حجم بلوري يتراوح بين 12–39 نانومتر، كما هو موضح من خلال حيود الأشعة السينية. تعرض صور FE-SEM لـ Fe2O3 NPs أشكال البنى النانوية، أو الأشرطة النانوية، اذ تكشف الخصائص البصرية للجسيمات النانوية Fe_2O_3 عن نطاق امتصاص وفجوة في نطاق الطاقة مع أقصى قدر من الامتصاص عند 231 نانومتر وفجوات طاقة بصرية تبلغ 3.8 فولت على التوالي، اذ تم دراسة تأثير الأسمدة النانوية (Fe_2O_3) على تطور وإنبات بذور حبة البركة من خلال هذا النشاط. وكان لمعاملات الدراسة تأثير كبير على فترة الإنبات، على سبيل المثال عند نقعها في معلق خميرة الخبز بتركيز 1 غم لتر$^{-1}$ انخفضت فترة الإنبات إلى 14.71 يومًا بعد أن كانت 18.10 يومًا في معاملة المقارنة، كما بين أقل نقعاً في 1 ملغم لتر$^{-1}$ من مستخلص خميرة الخبز النانوية كانت مدة الإنبات 14.16 يوماً مقابل 16.21 يوماً في معاملة المقارنة.

الكلمات المفتاحية : Fe_2O_3،الطريقة الحرارية المائية، سماد النانو، بذور حبة البركة، خلاصة الخميرة.