Effect of nano zinc in increasing the growth indicators of sunflower Helianthus annuus L. and controlling root rot and Damping off caused by the fungus Rhizoctonia solani

Rana Abdul Sahib Adm. 1 Muhannad Mohammad Amin Khalaf 2 Zainab Kazem Hassan 3
University of Basra, College of Agriculture
aranaagre@gmail.com ,zinabkadm006@gmail .com,Mohanad.ameen@uobasrah.edu.iq

Abstract

A field agricultural experiment was conducted using a randomized complete block design (RCBD), with treatments including mineral fertilizer 0-50-100% of the recommended fertilizer, the presence and absence of the pathogenic fungus R.solani (F1 and F0), the traditional fungicide Beltanoil and nano zinc fertilizer according to control treatment - Beltanoil - nano zinc and two levels 0-100% of the locally produced liquid organic fertilizer using the Bioreacter technology in the poultry field station affiliated to the College of Agriculture - University of Basra - Karmat Ali. Sunflower seeds Helianthus annuus L. were planted. Local cultivar. Three months after cultivation, the plants were harvested after calculating plant disease indicators (germination percentage, infection percentage and severity) and plant growth and yield indicators were estimated. The results showed the following: - The nano zinc fertilizer was significantly excelled in increasing the sunflower yield indicators of disc diameter, 1000 grain weight and total yield, which reached 28.5 cm, 88.69 g and 4.60 Meg . ha-1 at the above-mentioned yield indicators respectively, while mineral fertilization was excelled in leaf area and dry weight of the green part as they were 566.67 cm2 and 8.54 Meg ha-1 respectively compared to other treatments.There is a significantly excelled of mineral fertilization and nano zinc fertilizer in increasing the disc diameter and the weight of 1000 grains as they reached 30.9 cm and 96.72 g respectively after the severity of infection decreased by adding them (mineral and nano) to 15.83% compared to the fungicide and the control treatment (without the pathogenic fungus) as it reached 0%. The mineral and organic liquid fertilizers showed a significant superiority in the leaf area and dry weight of the green part of the sunflower, which reached 663.48 cm2 and 10.07 Megs ha-1, in addition to the leaf content of (nitrogen, phosphorus and potassium) which were 26.17, 5.34 and 21.09 g kg-1 respectively, compared to the control treatment (without addition) which reached 17.08, 2.99 and 13.91 g kg-1 respectively. The organic liquid treatment and nano zinc fertilizer also showed a significantly excelled in the highest total yield which reached 5.10 Meg.ha-1 and the lowest infection rate which was 10.33%.

Key words: nano zinc, sunflower, root rot , Damping off, Rhizoctonia solani

Introduction

Sunflower (Helianthus annuus L.) is one of the world's major oil crops. It is native to North America. Sunflower is grown mainly in the Black Sea region, where it accounts for more than 50% of the world's production [14] In Russia, higher seed and oil yield varieties have been discovered. The world's sunflower area today is about 23 million hectares and production is about 30 million tons. Sunflower is grown as an oil crop in Russia. It is healthy and has a high content of monounsaturated and polyunsaturated fatty acids, in addition to

ISSN 2072-3857

vitamin E. Sunflower is affected by some fungal pathogens, including Rhizoctonia solani, which causes sunflower root rot and Damping off [3]. This necrotic pathogen produces sclerotia (overwintering structures), survives for many years in soil or plant debris and then germinates under suitable conditions, giving rise to a fungus that attacks sunflower seedlings, causing necrotic lesions on the root and stem in addition to root rot. R. solani can cause various diseases on many plants, such as white blight, brown spots, wind blight, sheath blight, damping off and target spot (Srinivasan and Visalakchi, 2010). It is an important soil fungus in terms of pathogenicity and has a wide host range. It is a facultative plant pathogen and infects plants at different stages of their growth, as it can infect seeds and cause failure in their germination due to its enzymes capable of decomposing seed coats and consuming their contents through the secretion of amylase and lipase enzymes. The fungus also secretes some toxic compounds such as Pheylacetic and its hydroxyl derivatives such as Para-hydroxy and Beta-hydroxy. [28] It has the ability to infect the plant in its early stages of growth, after the formation of the stalk and the peduncle, causing failure of the plant to emerge above the soil surface, especially if there is high humidity and rich organic matter in the soil, as it gradually analyzes the area of the stem close to the soil surface, starting from the cortex area and entering the internal tissues, making this area soft and unable to carry the aerial parts of the plant, so it falls at the slightest air current, causing the seedlings to fall. This condition occurs during the seedling formation stage, as the disease has a high ability to secrete external enzymes capable of decomposing various plant tissues, such as Pectinase, which is capable of decomposing the cell wall and reaching the inside of the cell and killing it, and the enzyme Cellulase, hemi Cellulase Protease, Phenol Oxidase, (Gawade, et al. 2017(

The development and spread of the fungus are affected by environmental factors, as the best temperature for the growth of the fungus R.solani is 25°C, and a decrease in temperature to less than 15°C and an increase to more than 30°C leads to a decrease in growth, and the best pH for its growth and development is 5.5 . The symptoms of root and stem rot disease appear at the beginning of infection in the form of a light red discoloration that later becomes dark red to brown to cover the stem and the shoot under the soil surface, or the symptoms appear in the form of longitudinal cracks along the root, the main root, with the death of small lateral roots and cracking of the stem [2,13], . [11]indicated that isolates of the fungus R.solani differ in infecting plants, as those that are capable of infecting cucumber plants may not be capable of infecting watermelon, turnips, cauliflower, beans, spinach, and onions, and they are not capable of infecting wheat, rice, radish, cabbage, and carrots. Micronutrient deficiencies, especially iron, zinc and manganese, are well-known and of great importance in developing countries. It is estimated that about 30 billion people worldwide are affected in one way or another by zinc and iron deficiency. Their negative effects are alarming, which has prompted the adoption of a number of strategies to improve the efficiency of zinc fertilizer, as more than 95% of the added zinc is fixed by precipitation and adsorption, depending on factors that encourage loss, such as high soil acidity, low soil organic matter content, and decreased available zinc (Chrissarthopoulos et al. 2014). Zinc may also interfere with orthophosphate (a

ISSN 2072-3857

negative ion), and calcium may compete with zinc, as in calcareous soils, for adsorption sites, decreasing the amount of zinc available to the plant[17] . Recently, it seems that nanotechnology enriched naturally or manufactured with zinc has improved the zinc nutrition of rice, regardless of whether it is grown submerged or dry (Yuvaraj and Subramania ,2014), and (Broos et al. 2007) indicated that nanomaterials can be added in the form of more soluble fertilizers, as the smaller size and larger surface area of nano zinc oxide can affect the solubility, diffusion and quantity available to the plant compared to regular zinc. There are many studies that have shown the possibility of using nanoparticles in combating diseases caused by various bacterial and fungal pathogens [21] and after traditional methods of disease management relied heavily on chemical fungicide s that have negative effects on human health and disrupt the ecological balance, as nanomaterials such as nanosilver have high effectiveness against many plant pathogens [10,, as (Kumar, 2008) showed the possibility of using titanium dioxide in a study conducted in India, as it showed the possibility of using nanosilver particles to protect wheat plants from infection with leaf spot disease caused by the fungus Biopolaris sorokiniana. In Egypt, it also aimed to use nano zinc oxide particles to protect corn plants from infection with late wilt disease, as several concentrations were tested on the pathogen Cephalosporium magdis and showed high efficiency in inhibiting this pathogen. Farhat et al. (2018) explained the effect of nano titanium after testing three concentrations of the material, which are (50, 100 and 150) ppm, as the rate of infection severity of wheat plants with powdery mildew disease decreased by 89.3, 48.6 and 91.0%, respectively. In Iraq, [15] studied the effect of nano zinc particles and nano magnesium particles by treating with three concentrations of each material (1, 3, 5) g L-1 when infected with early blight disease Alternaria on tomatoes, as it was found that there was an inhibition rate of more than 50% and these concentrations showed high efficiency in inhibiting the causative agent of the disease on tomatoes. Chemical fertilizers are inorganic or mineral chemical compounds that contain elements added to encourage plant growth and production because they contain more than one nutrient element (Behera and Panda, 2009).Chemical fertilizers are added to the soil to be absorbed by the roots or to the leaves through foliar spraying. Mineral fertilizers are prepared industrially in different formulas and concentrations, individually containing one element or a compound of more than one nutrient, such as major elements such as nitrogen, phosphorus, and potassium. As for nitrogen, it is responsible for encouraging leaf growth and the formation of protein and chlorophyll, while phosphorus is concerned with root growth and the storage of energy compounds ATP, and potassium for the development of flowers, fruits, and water relations of the plant [18] In general, the benefit of added chemical fertilizers in terms of recovery and absorption efficiency does not exceed 30-60% for nitrogen, 10-20% for phosphorus, and 30-50% for potassium, and the rest is lost to the environment as ammonia evaporation from urea and nitrogen loss depending on factors related to the soil and the surrounding environment [21] which causes economic loss of fertilizers and exposes soil, water and pollution, or precipitation or adsorption of orthophosphate in basic and calcareous soils [24] in addition to increasing rates of potassium fixation and decreasing its ready form (soluble and exchangeable) depending on soil properties. [5] Liquid organic fertilizer is a natural and sustainable source of nutrients (nitrogen, phosphorus and potassium) that plants need [29] It is produced from the decomposition of organic materials such as plant or animal waste or food waste and through various fermentation methods, especially filtering and diluting it with water to obtain ready-to-use liquid fertilizer [16] Liquid organic fertilizer plays a role in improving the quality and health of the soil (Soil health) by increasing the concentration of nutrients in the form and quantity ready for them and improving their ability to retain water and increase productivity. In addition, liquid organic fertilizer enhances the diversity of beneficial bacteria and fungi in the soil, which helps improve soil aeration and decompose organic materials at faster rates compared to non-fermented (fresh) fertilizers, as it is effective in using organic agriculture and reducing the amounts of mineral fertilizer [16[

Materials and methods

The experiment was designed Factorial according to the design of the completely randomized blocks, which included four factors and three replicates, and included:

The first factor is mineral fertilizer, and it was added at three levels, including:

A- L0, the control treatment (without any addition.(

B- L1, 50% of the fertilizer recommendation was added.

C- L2, 100% of the fertilizer recommendation was added.

The second factor is the treatment with the fungus R. solani.

A- F0, the control treatment (without the fungus.(

B- F1, the treatment with the fungus R. solani.

The third factor was added at three levels, including:

A- P0, the control treatment (without any addition.(

B- pT, the traditional commercial fungicide Beltanoil. It was added according to the recommendation mentioned on the box.

C- pN, the nano zinc fertilizer (12% zinc) was added at one level at a rate of 6 kg per hectare, according to the recommendation mentioned on the box.

The fourth factor is the liquid organic fertilizer fermented anaerobic fermentation in the bioreactor device designed according to the internationally approved standards in a previous study [8], added at two levels (0-100), which are:

A-O0 control treatment (without any addition.(

B-O1 liquid organic fertilizer.

The soil was plowed perpendicularly, then leveled and divided into three equal sectors, each sector represents a replicate, and each sector was divided into (36) experimental units according to the number of experimental treatments, then the experimental treatments were distributed randomly within the same sector, the dimensions of the experimental unit are 2 x 0.75 m2, where the experimental unit contains 5 holes, the distance between one experimental unit and another is 30 cm and the distance between one sector and another is 60 cm, as shown in Figure (1), where the fungus R. solani was added at a weight of 5 gm per hole according to the experimental treatments and the fungus was left in the hole for 48 hours before cultivation in order to adapt it to the added soil conditions, and the mineral recommendation was added using the hole method, where the depth of the hole was 5 cm and a distance of 3 cm from the seed for each of urea) 46% (N) at a rate of 200 kg N ha-1

ISSN 2072-3857

and in two batches, the first at cultivation and the second one month after cultivation and triple superphosphate (p% 20.21) at a rate of 80 kg P ha-1, potassium sulfate) 43% K) At a rate of 100 kg K ha-1, based on the mineral recommendation of the Ministry of Agriculture/General Authority for Agricultural Services 1990, the liquid organic fertilizer produced from the bioreactor was added in quantities calculated on the basis of its nitrogen content equivalent to nitrogen in the mineral recommendation and according to the levels of the above-mentioned treatments by digging a longitudinal line inside each hole with a depth of 5 cm and a width of 20 cm in parallel in order to distribute the fertilizer on the experimental unit in a homogeneous manner. Then the experimental holes were planted with sunflower seeds. Helianthus annus L. Local cultivar. Three seeds were placed inside each hole and were thinned after germination and emergence of seedlings to one plant. Crop service operations were carried out by weeding combating agricultural pests with insecticides and maintaining the holes. The plants were irrigated by drip irrigation and harvested 90 days after cultivation

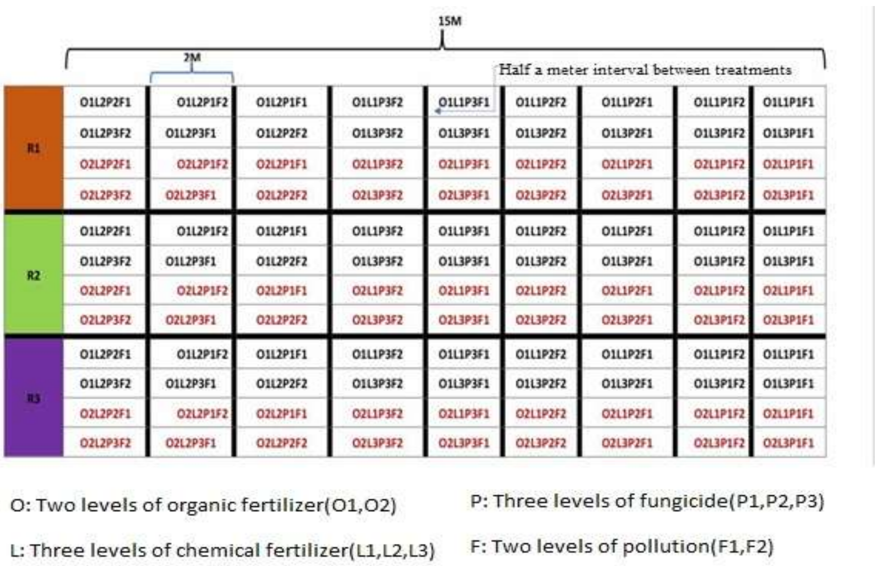

Figure (1) Field experiment diagram

Field and laboratory measurements

Leaf samples were collected at the beginning of flowering at the maximum activity of vegetative growth and the fourth upper integrated leaf was taken from the plant [19] The samples were placed in paper bags and after being transferred to the laboratory and wiped with cotton soaked in distilled water, they were then dried in the oven at 70°C and ground and sieved through a sieve with a hole size of 1 mm and kept until the necessary tests were carried out, including-:

Disc diameter (cm(

The diameter of the flower disc of the sunflower plant was measured using a measuring tape.

Leaf area (cm2(

The maximum length of the sunflower leaf was measured with a tape measure and the maximum width, then the leaf area was calculated from the product of the maximum length of the leaf × the maximum width for each two plants of each treatment × the correction factor 0.65[23[

Dry weight of the vegetative part (Meg. ha-1(

The weight of the fresh vegetative part was taken in the early growth stage from two plants of each experimental unit after removing the discs from them and washing them with distilled water and cutting them into small pieces and then leaving them to air dry, then placed in perforated paper bags in an oven at a temperature ranging between 65-70°C for 72 hours, then weighed again after drying as the dry weight of the vegetative part.

Results and discussion

1-1Disc diameter

It appears from the results of Table 1 (and the statistical analysis (Appendix 2) that there is a significant effect (0.05) P≥ of soil treatment with the fungus Rhizoctonia solani on the average disc diameter of the sunflower Helianthus annuus L., as it decreased from 24.9 cm when compared to F0 to 23.9 cm when treated with the studied fungus. This is what many studies have indicated that the fungus R. solani possesses enzymes capable of decomposing seed coats and consuming their contents through the secretion of amylase and Lipase enzymes. The fungus also secretes some toxic compounds such as Pheylacetic and its hydroxyl derivatives such as Para-hydroxy and Beta-hydroxy Xue, et al. (2018)) It also has a high ability to secrete external enzymes capable of decomposing various plant tissues such as Pectinase, which is capable of decomposing the cell wall and reaching the inside of the cell and killing it Gawade. The results of Table (1) and the statistical analysis (Appendix 2) also showed that there is a significant effect (P≥ 0.05) of soil treatment with levels of mineral fertilization L1 and L2 on the average disc diameter of sunflower Helianthus annuus L., as it increased from 20.9 cm when comparing L0 (without addition) to 24.9 and 27.3 cm at levels L1 and L2, respectively. This is consistent with both Mengal and Kirkby (1982 and [4,6], who showed the division of the mineral dose such as urea and triple superphosphate. Mineral nutrients in general (and nitrogen and phosphorus) in particular have a role in providing crops with the basic elements for the early growth stages due to the role of nitrogen and phosphorus in vital processes such as photosynthesis, respiration, and the formation of amino acids and proteins in relation to nitrogen, as well as the function of phosphorus in the formation of production compounds. ATP energy, nucleic acid production, and encouraging vegetative growth of the crop and its reflection on growth and productivity indicators, especially the disc diameter. As for the interaction between mineral fertilization (L0, L1, and L2) and the fungus Rhizoctonia solani (F0 and F1), the results in Table (1) and the statistical analysis (Appendix 3) show that there is a non-significant effect (P≥ 0.05) on the disc diameter of the sunflower Helianthus annuus L., as the largest diameter reached 27.8 cm at L2F0 and the smallest diameter was 20.3 cm at L0F1. The results of Table (1) and the statistical analysis (Appendix 2) also indicated that there is a significant effect (P≥ 0.05) for treating the soil with the fungicide PT (Beltanoil), nano zinc fertilizer PN on the average disc diameter of the sunflower Helianthus annuus L., as it increased from 22.07 cm when compared to P0 to 22.7 and 28.5 cm at PT and PN respectively, which

ISSN 2072-3857

confirms the importance of adding the nutrient element (such as zinc in nano form, since zinc is an essential element that plays a role in the enzymatic activity of vital activities in the plant, especially in the advanced stages of growth [26] and (Kraeova and Jampilek, 2015 and [1] which develops the crop's resistance to the pathogen, as for the interaction between mineral fertilization (L0, L1 and L2) and each of the fungicide ((Beltanoil, nano zinc fertilizer (P0, PT and PN), the results of Table (1) and the statistical analysis (Appendix 3) indicate the presence of an insignificant effect (P≥ 0.05) on the disc diameter of the sunflower Helianthus annuus L., as the highest value of 30.9 cm was recorded at L2PN and the lowest value of 18.5 cm at L0P0. The results of Table (1) and the statistical analysis (Appendix 3) showed that there is a significant effect (P≥ 0.05) for the interaction between each of the fungicide ((Beltanoil, nano zinc fertilizer (P0, PT and PN) and the fungus Rhizoctonia solani (F0 and F1) in the diameter of the disc of the sunflower Helianthus annuus L. The largest diameter was 28.7 cm at PN F0 and the smallest diameter was 20.9 cm at F1 P0. The advantages of adding the nutrient element zinc in a nano form may be a competitor to what is added from traditional fungicide s without any side effects, as the nano nature of the element, especially Zn-NPS, enables it to penetrate the cells of the pathogen and disrupt most of its organelles (mitochondrion and others), in addition to raising the cells, which makes it a strong competitor to the traditional fungicide [1]. The results of Table (1) and the statistical analysis (Appendix 2) also showed that there is a significant effect (P≥ 0.05) of treating the soil with liquid organic fertilizer produced by anaerobic fermentation 1 O on the average disc diameter of the sunflower crop Helianthus annuus L., as it increased from 22.9 cm when compared to O0 to 25.9 cm when adding liquid organic fertilizer produced by anaerobic fermentation O1. The high quality specifications of liquid organic fertilizer fermented anaerobically, such as its high content of ready nutrients (ammonium and others) and its freedom from pathogens as a result of high temperatures during anaerobic fermentation [8,27] are considered a source of support for the plant in resisting diseases and reducing the severity and rate of infection from the seedling stage until maturity. As for the interaction between organic fertilization (O0 and O1) and mineral fertilization (L0, L1 and L2), the results in Table (1) and the statistical analysis (Appendix 3) showed a significant effect (P≥ 0.05) on the disc diameter of the sunflower Helianthus annuus L., as the largest diameter was 28.3 cm at O1L2 and the smallest diameter was 19.6 cm at L0 O0. This is due to the presence of the integrated dose (mineral-organic), as what is lost from mineral nutrients due to soil obstacles must be compensated by the elements released from the decomposition of organic waste (such as poultry waste) by the anaerobic digestion method [4 Arnous, (2022) and. The results of Table (1) and the statistical analysis (Appendix 3) also showed that there is an insignificant effect (P≥ 0.05) when interacting between organic fertilization (O0 and (O1 and the fungus Rhizoctonia solani (0F and F1) in the disc diameter of the sunflower Helianthus annuus L. The largest diameter was 26.4 cm at O1F0 and the smallest diameter was 22.4 cm at O0F1. The results of Table (1) and the statistical analysis (Appendix 3) showed that there is an insignificant effect (P≥ 0.05) of the interaction between organic fertilization (O0 and (O1) and each of the fungicide s ((Beltanoil, nano zinc fertilizer P0)

ISSN 2072-3857

and PT and (PN) on the disc diameter of the sunflower crop for the sunflower Helianthus annuus L., the largest diameter was 30.1 cm at O1PN and the smallest diameter was 20.8 cm at O0P0.

Table (1) shows the effect of the study factors and bi-interactions between them on the disc diameter (cm) of the sunflower Helianthus annuus L. at the end of the growing season.

average	**fungus *R.solani***		**Fungicide and nano zinc fertilizer**	**average**	**fungicide (Beltanoil) Nano zinc fertilizer**			**average**	**fungus *R.solani***		**Mineral fertilization**
	F_1	**F_0**			**P_N**	**P_T**	**P_0**		**F_1**	**F_0**	
22.07	20.9	23.2	**P_0**	20.9	25.5	18.9	18.5	20.9	20.3	21.5	**L_0**
22.7	22.5	22.9	**P_T**	24.9	29.0	23.5	22.3	24.9	24.5	25.4	**L_1**
28.5	28.2	28.7	**P_N**	27.3	30.9	25.8	25.3	27.3	26.8	27.8	**L_2**
	23.9	24.9	**average**		28.5	22.7	22.07		23.9	24.9	**average**
PF				LP		P		LF	F	L	**$L.S.D_{0.05}$**
1.198				1.467		0.847		1.198	0.691	0.847	

average	**fungicide)(Beltanoil Nano zinc fertilizer**			**average**	**fungus *R.solani***		**average**	**Mineral fertilization**			**Organic fertilization**
	P_N	**P_T**	**P_0**		**F_1**	**F_0**		**L_2**	**L_1**	**L_0**	
22.9	26.8	21.2	20.8	22.9	22.4	23.4	22.9	26.4	22.8	19.6	**O_0**
25.9	30.1	24.2	23.3	25.9	25.4	26.4	25.9	28.3	27.1	22.3	**O1**
	28.5	22.7	22.07		23.9	24.9		27.3	24.9	20.9	**average**
OP				OF			OL		O		**$L.S.D_{0.05}$**
1.198				0.978			1.198		0.691		

Leaf area

The results of Table (2) and the statistical analysis (Appendix 2) show that there is a significant effect (P≥ 0.05) of soil treatment with the fungus Rhizoctonia solani on the average leaf area of the sunflower Helianthus annuus L., as it decreased from 441.80 cm2 when comparing F0 to 423.83 cm2 when F1 infection with the fungus treated with the studied fungus that the fungus R. solani has, and this was in agreement with Abbas, (2021) in her study on eggplant and Al-Mansouri, (2022) in her study on wheat. The results of

ISSN 2072-3857

Table (2) and the statistical analysis (Appendix 2) also showed that there is a significant effect (P≥ 0.05) of the levels of mineral fertilizer L1 and L2 on the average leaf area of the sunflower Helianthus annuus L., as it increased from 312.24 cm2 when comparing L0 (without addition) to 419.54 and 566.67 cm2 at levels L1 and L2 respectively, which confirms the significant effect of dividing the mineral dose of fertilizer, especially in calcareous soils in which mineral fertilizer is exposed to a series of reactions (Mengal and Kirkby, 1982) leading to its loss over time and its effect on most growth indicators such as leaf area. As for the interaction between mineral fertilization (L0, L1 and L2) and the fungus Rhizoctonia solani (F0 and F1), the results in Table (2) and the statistical analysis (Appendix 3) show that there is a non-significant effect (P≥ 0.05) on the leaf area of the sunflower Helianthus annuus L., as the highest value reached 575.50 cm2 at L2F0 and the lowest value reached 307.33 cm2 at L0F1. The results of Table (2) and the statistical analysis (Appendix 2) also indicated that there is a significant effect (P≥ 0.05) of treating the soil with the fungicide PT (Beltanoil), nano zinc fertilizer PN on the average leaf area of the sunflower Helianthus annuus L., as it increased from 317.37 cm2 when comparing P0 to 412.87 and 514.21 cm2 at PT and PN. In sequence, which encourages the adoption of nano zinc fertilizer as an alternative to the traditional fungicide ((Beltanoil in controlling the R. Solani fungus [7] in his study on wheat crops and [12] and with regard to the interaction between mineral fertilizer levels (L0, L1 and L2) and each of the fungicide ((Beltanoil, nano zinc fertilizer (P0, PT and PN), the results of Table (2) and the statistical analysis (Appendix 3) indicate the presence of a significant effect (0.05) P≥ on the leaf area of the sunflower Helianthus annuus L., as the highest value was 653.80 cm2 at L2PN and the lowest value was 256.11 cm2 at L0P0. The result agreed with (Khader, 2007), who confirmed that the percentage of inhibition of infection with plant pathogens was high in the presence of chemical nutrients and the fungicide enhanced with nutrients Like zinc or copper, and Abdullah agreed with him (2015). The results of Table (15) and the statistical analysis (Appendix 3) also showed that there is a significant effect (0.05) P≥ for the interaction between each of the fungicide ((Beltanoil, nano zinc fertilizer (P0, PT and PN) and the fungus R. solani (F0 and F1) on the leaf area of the sunflower Helianthus annuus L., as the largest area was recorded at 518.02 cm2 at PN F0 and the smallest area was 337.32 cm2 at F1 P0, because the nanoparticles have distinctive properties, including their ability to dissolve clearly and release the active substance from them in a slow and gradual manner and provide protection for the biological material, which in turn leads to oxidative stress in the fungal cells. Also, the nanoparticles of the compounds and their ions may cause genetic toxicity due to their destruction of the genetic material (DNA) of the fungus. [21]The results of Table (2) and the statistical analysis (Appendix 2) also showed that there is a significant effect (P≥ 0.05) of treating the soil with liquid organic fertilizer produced by anaerobic fermentation 1 O on the average leaf area of the sunflower Helianthus annuus L., as it increased from 367.78 cm2 when comparing O0 to 497.86 cm2 when adding liquid organic fertilizer produced by anaerobic fermentation O1. The result agreed with Arnos (2022), in his study on barley and wild crops, (2023) in her study on sunflowers. As for the interaction between organic fertilization (O0 and O1) and mineral fertilization (L0, L1 and L2), the results in Table (2) and the statistical analysis (Appendix 3) showed a significant effect (P≥ 0.05) on the leaf area of the sunflower Helianthus annuus L., as the largest area was 663.48 cm2 at O1L2 and the smallest area was 250.07 cm2 at L0 O0. This was consistent with [4] in his study on the sunflower crop, as it showed the importance of treating the stressed sunflower crop with anaerobically fermented organic materials for two reasons: the first is the maturity of the fermented fertilizer and its richness in ready nutrients such as nitrogen and phosphorus and its high content of carboxylic and phenolic active groups and their importance in improving the composition and structure of the soil planted with the stressed crop. The second reason is that the anaerobically fermented organic fertilizer is a sustainable supporter of soil health. And its productivity for the upcoming agricultural experiments if applied by[4,20] . The results of Table (2) and the statistical analysis (Appendix 3) also showed that there is a significant effect (0.05) P≥ when interacting between organic fertilization (O0 and (O1) and the fungus Rhizoctonia solani (0F and F1) on the leaf area of the sunflower Helianthus annuus L. The largest area was 512.33 cm2 at O1F0 and the smallest area was 367.78 cm2 at O0F1, meaning that the liquid organic fertilizer fermented anaerobically contains ready nutrients such as nitrogen released from ammonia and others, and since it is free of fungal pathogens because it was exposed to high temperatures during fermentation in the digester, it is considered a supporter of the plant to resist diseases, which enhances the reduction of the rate and severity of infection with the disease caused by the fungus R.solani [29]In addition, the results of Table (2) and the statistical analysis (Appendix 3) show that there is a significant effect (P≥ 0.05) of the interaction between organic fertilization (O0 and (O1) and each of the fungicide s ((Beltanoil, nano zinc fertilizer (P0, PT and PN) on the leaf area of the sunflower Helianthus annuus L., as the largest area reached 586.09 cm2 at O1PN and the smallest area at O0P0 and was 310.70 cm2, which confirms the importance and necessity of adding mineral nutrients such as zinc and fermented organic fertilizer, whether during the period of infection with the studied fungus, specifically in the early growth stages of the life of the sunflower crop, as a technical method supporting what is known as integrated control of crops exposed to infection with fungal pathogens [15,29 ..[

Table (2) shows the effect of the study factors and the bi-interactions between them on the area Leaf diameter (cm2) of sunflower Helianthus annuus L. at the end of the growing season.

average	**fungus *R.solani***		**fungicide and Nano zinc fertilizer**	**average**	**fungicide (Beltanoil) Nano zinc fertilizer**			**average**	**fungus *R.solani***		**Mineral fertilization**
	F_1	**F_0**			**P_N**	**P_T**	**P_0**		**F_1**	**F_0**	
371.37	337.32	405.42	**P_0**	312.24	395.98	284.64	256.11	312.24	307.33	317.16	**L_0**
412.87	416.16	409.58	**P_T**	419.54	492.86	405.84	359.91	419.54	406.32	432.75	**L_1**
514.21	518.02	510.41	**P_N**	566.67	653.80	548.13	498.10	566.67	557.84	575.50	**L_2**
	423.83	441.80	**average**		514.21	412.87	371.37		423.83	441.80	**average**
PF				LP		P		LF	F	L	**$L.S.D_{0.05}$**
12286				15047		8687		12286	7093	8687	

average	**fungicide) (Beltanoil Nano zinc fertilizer**			**average**	**fungus *R.solani***		**average**	**Mineral fertilization**			**Organic Fertilization**
	P_N	**P_T**	**P_0**		**F_1**	**F_0**		**L_2**	**L_1**	**L_0**	
367.78	442.34	350.28	310.70	367.78	364.28	371.27	367.78	469.87	383.38	250.07	**O_0**
497.86	586.09	475.45	432.04	497.86	483.39	512.33	497.86	663.48	455.69	374.41	**O1**
	514.21	412.87	371.37		423.83	441.80		566.67	419.54	312.24	**average**
OP				OF			OL		O		**$L.S.D_{0.05}$**
12286				10031			12286		7093		

average	**fungus *R.solani***		**fungicide and Nano zinc fertilizer**	**average**	**fungicide (Beltanoil) Nano zinc fertilizer**			**average**	**fungus *R.solani***		**Mineral fertilization**
	F_1	**F_0**			**P_N**	**P_T**	**P_0**		**F_1**	**F_0**	
371.37	337.32	405.42	**P_0**	312.24	395.98	284.64	256.11	312.24	307.33	317.16	**L_0**

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412.87	416.16	409.58	**P_T**	419.54	492.86	405.84	359.91	419.54	406.32	432.75	**L_1**
514.21	518.02	510.41	**P_N**	566.67	653.80	548.13	498.10	566.67	557.84	575.50	**L_2**
	423.83	441.80	**average**		514.21	412.87	371.37		423.83	441.80	**average**
PF				LP		P		LF	F	L	**L.S.D$_{0.05}$**
12286				15047		8687		12286	7093	8687	
average	**fungicide) (Beltanoil Nano zinc fertilizer**			**average**	**fungus *R.solani***		**average**	**Mineral fertilization**			**Organic Fertilization**
	P_N	**P_T**	**P_0**		**F_1**	**F_0**		**L_2**	**L_1**	**L_0**	
367.78	442.34	350.28	310.70	367.78	364.28	371.27	367.78	469.87	383.38	250.07	**O_0**
497.86	586.09	475.45	432.04	497.86	483.39	512.33	497.86	663.48	455.69	374.41	**O1**
	514.21	412.87	371.37		423.83	441.80		566.67	419.54	312.24	**average**
OP				OF			OL		O		**L.S.D$_{0.05}$**
12286				10031			12286		7093		

Dry weight of the vegetative part

It appears from the results of Table (3) and the statistical analysis (Appendix 2) that there is a significant effect (P≥ 0.05) of treating the soil with the fungus R. solani on the average dry weight of the vegetative group of the sunflower Helianthus annuus L., as it decreased from 7.33 Meg. ha-1 when compared to F0 to 6.99 Meg. ha-1 when treated with the studied fungus, and it was consistent with Parmeter, 2023) (Rahman et al, 2020)), as fungal infections led to a loss of approximately 50% of the yield, in addition to the role of environmental and climatic conditions that encourage an increase in the rate and severity of infection, thus stopping the important vital and physiological activities of the plant with damage to the ecological and natural systems (Saxena, et al 2024). The results of Table (3) and the statistical analysis (Appendix 2) showed that there is a significant effect (P≥ 0.05) of the levels of mineral fertilization L1 and L2 on the average dry weight of the vegetative group of sunflower Helianthus annuus L., as it increased from 5.45 Meg. ha-1 when comparing L0 (without addition) to 7.51 and 8.53 Meg. ha-1 at levels L1 and L2, respectively. This is consistent with both [4,6, Mengal and Kirkby (1982), who showed that the division of the mineral dose (urea and triple superphosphate) from mineral nutrients in general (and nitrogen and phosphorus) in particular plays a role in providing the crop with the basic elements for the early growth stages due to their role (nitrogen and phosphorus) in vital processes such as photosynthesis, respiration, and the formation of amino acids and proteins with respect to nitrogen and the formation of

ISSN 2072-3857

production compounds. ATP energy and nucleic acid production for phosphorus and encourage vegetative growth and its reflection on the dry weight of the crop, as for the interaction between mineral fertilization (L0, L1 and L2) and the fungus R. solani (F0 and F1), the results in Table (3) and the statistical analysis (Appendix 3) show that there is a significant effect (P≥ 0.05) on the dry weight of the vegetative group of sunflower Helianthus annuus L., as the highest dry weight reached 8.67 Meg ha-1 at L2F0 and the lowest dry weight 5.19 Meg ha-1 at L0F1, which confirms the importance of mineral nutrients in raising the resistance of the crop to the pathogen and the crop's need for nutrients, especially in the early growth stages such as germination and seedling formation (Janbon et al., 2019). The results in Table (3) and the statistical analysis (Appendix 2) also indicated that there is an effect Significantly (P≥ 0.05) for soil treatment with the traditional fungicide (PT) Beltanoil and nano zinc fertilizer PN in the average dry weight of the vegetative group of sunflower Helianthus annuus L., as it increased from 6.31 Meg ha-1 when compared to P0 (no adding) to 6.84 and 8.34 Meg ha-1 at PT and PN, respectively. Beltanoil is one of the most effective fungicide s in controlling the R. solani fungus, as confirmed by the results of the laboratory experiment, Table (2). However, it is often considered one of the fungicide s that pollute the soil, especially with traditional control methods that result in the accumulation and collection of toxins in the soil and the vegetative group of the crop. Therefore, nano zinc fertilizer can be a nutritious fertilizer and support for plant resistance to disease on the one hand, and a preventive alternative for the crop by improving the rate of seed germination and seedling growth and encouraging its vegetative growth on the other hand. (Kraeova and jampilek,2015 (

This was confirmed by the American Agricultural Laboratory in 2003 that nanofertilizers have unique properties due to their small size to surface area ratio, which increases the absorption surface of nutrients and thus increases the photosynthesis process and increases the production of dry matter of the crop [21]. As for the interaction between mineral fertilization (L0, L1, and L2) and each of the fungicide ((Beltanoil and nanozinc fertilizer (P0, PT, and PN), the results of Table (3) and the statistical analysis (Appendix 3) indicate the presence of a significant effect (P≥ 0.05) on the dry weight of the vegetative group of sunflower Helianthus annuus L., as the highest dry weight was 9.70 Meg ha-1 at L2PN and the lowest dry weight was 4.52 Meg ha-1 at L0P0. The superiority of treatment with nanozinc fertilizer may be due to the role of the zinc element in particular in the plant's tolerance to biological stresses and resistance to pests and diseases. As an enzyme catalyst for vital processes such as cell division and the development of plant tissue immunity to diseases (such as Damping off and root rot), it was consistent with what was reached by (Umair Hassan et al., 2020). It was also shown from the results of Table (3) and the statistical analysis (Appendix 3) that there is a significant effect (0.05) P≥ when interacting between each of the fungicide ((Beltanoil and nano zinc fertilizer (P0, PT and PN) and the fungus R.solani (F0 and F1) on the dry weight of the vegetative group of the sunflower Helianthus annuus L., as the highest dry weight was recorded at 8.36 Meg ha-1 at PN F0 and the lowest dry weight was 5.78 Meg ha-1 at F1 P0, which confirms the necessity of combating the studied fungus, especially with nano zinc fertilizer, and this

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was confirmed by the results of the pathological experiment (Figure 1) in stating the inhibitory effect of concentrations Whether from the traditional fungicide (Beltanoi or nano zinc in inhibiting the radiative growth and dry weight of the studied fungus and what was consistent with Abbas, (2021) as the results of Table (3) and the statistical analysis (Appendix 2) showed that there is a significant effect (P≥ 0.05) of treating the soil with liquid organic fertilizer produced by anaerobic fermentation 1 O on the average dry weight of the green group of the sunflower Helianthus annuus L. As it increased from 5.97 Meg ha-1 when compared to O0 to 8.36 Meg ha-1 at O1, and this is consistent with [4] as it was found that treating the soil with liquid organic fertilizer produced by anaerobic digester gave a highly significant effect on the average plant height and dry weight of the sunflower crop. As for the interaction between organic fertilization (O0 and O1) and mineral fertilization (L0, L1 and L2), the results in Table (3) and the statistical analysis (Appendix 3) showed a significant effect (P≥ 0.05) on the dry weight of the sunflower crop Helianthus annuus L., as the highest dry weight was recorded at 10.07 Meg ha-1 at L2 O1 and the lowest dry weight was 4.93 Meg ha-1 at L0 O0. This was consistent with what Arnos (2022) reached in his study on the barley crop, which confirmed the importance of compensating or mixing the organic fertilizer produced from the bioreactor with urea fertilizer to reach maximum productivity. The results of Table (3) and the statistical analysis (Appendix 3) also showed that there was an insignificant effect (P≥ 0.05) when interacting between organic fertilization (O0 and O1) and the fungus R. solani (0F and F1) on the dry weight of the vegetative group of sunflower Helianthus annuus L., as the highest dry weight was 8.53 Meg ha-1 at O1F0 and the lowest dry weight was 5.80 Meg ha-1 at O0F1.

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Also, the results of Table (3) and the statistical analysis (Appendix 3) show that there is a significant effect (P≥ 0.05) of the interaction between organic fertilization (O0 and (O1) and each of the fungicide s and nano zinc fertilizer (P0, PT and (PN) on the dry weight of the vegetative group of sunflower Helianthus annuus L. The highest dry weight was recorded at 9.15 Meg ha-1 at O1PN and the lowest dry weight at O0P0 and was 5.06 Meg ha-1%. Thus, nano zinc fertilizer can be considered as organic nanoparticles (prepared on organic carriers) since its presence in the composition of nano fertilizer does not conflict with the addition of organic fertilizer produced by the locally designed and constructed bioreactor [4] as an increase in the percentage of the active oxidizing substance (carboxylic and phenolic) was found in the liquid organic fertilizer prepared by anaerobic fermentation

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Table (3) shows the effect of Study factors and their interactions on the dry weight of the shoot (mcg ha-1) of sunflower Helianthus annuus L. at the end of the growing season.

average	**fungus *R.solani***		**fungicide and Nano zinc fertilizer**	**average**	**fungicide Beltanoil Nano zinc fertilizer**			**average**	**fungus *R.solani***		**Mineral fertilization**
	F1	**F0**			**PN**	**PT**	**P0**		**F1**	**F0**	
6.32	5.78	6.86	**P0**	5.45	6.66	5.19	4.52	5.45	5.19	5.72	**L0**
6.83	6.85	6.82	**PT**	7.51	8.67	7.19	6.67	7.51	7.40	7.62	**L1**
8.35	8.34	8.36	**PN**	8.54	9.70	8.14	7.76	8.54	8.40	8.67	**L2**
	6.99	7.34	**average**		8.35	6.84	6.31		6.99	7.34	**average**
PF				LP		P		LF	F	L	**L.S.D$_{0.05}$**
0.050				0.062		0.035		0.050	0.029	0.035	

average	**fungicide Beltanoil Nano zinc fertilizer**			**average**	**fungus *R.solani***		**average**	**Mineral fertilization**			**Organic Fertilization**
	PN	**PT**	**P0**		**F1**	**F0**		**L2**	**L1**	**L0**	
5.97	7.19	5.68	5.06	5.97	5.80	6.15	5.97	7.01	5.99	4.93	**O0**
8.36	9.51	8.00	7.57	8.36	8.19	8.53	8.36	10.07	9.03	5.98	**O1**
	8.35	6.84	6.31		6.99	7.34		8.54	7.51	5.45	
OP				OF			OL		O		**L.S.D$_{0.05}$**
0.050				0.041			0.050		0.029		

References

.1 Abbas, Janan Abdul Karim (2021). Evaluation of the efficiency of the two compounds (nano titanium dioxide and zinc oxide) in protecting wheat plants from infection with root rot and Damping off caused by the fungus Rhizoctonia solani Kuhn.. Master's thesis. College of Agriculture. University of Basra.

.2 Agrios, G. N. (2005). Plant Pathology. 5th edition. Elsevier academic. press, USA. 998 pp

ISSN 2072-3857

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.3
Al-Askar, A. A. A., Ghoneem, K. M., & Rashad, Y. M. (2012). Seed-borne mycoflora of alfalfa (Medicago sativa L.) in the Riyadh Region of Saudi Arabia. Annals of microbiology, 62, 273-281.
.4 Al-Baria, Naba Othman Muhammad (2023). Comparison of aerobic and anaerobic fermentation methods for poultry waste and their role in some soil properties and growth and yield components of sunflower (Helianthus annuus L.). Master's thesis. College of Agriculture. University of Basra. Iraq.
.5 Alla, H. N. , Helmy, S. A. M. (2022). Response of sugar beet to sandy soil amended by zeolite and potassium sulfate fertilization.
.6 Al-Rubaie, Fadhel Aliwi Attia (2011). The effect of cultivar, gibberellin acid, compound fertilizer, mineral fertilizer and their interactions on the growth and active compounds of chamomile plant (Chamomilla Maternicaria). PhD thesis. College of Education. Ibn Al-Haitham University. University of Baghdad. Iraq.
.7 Al-Tawki, Muhammad Abd Muhammad (2022). The effect of spraying chelated and nano zinc fertilizers on the growth and quantitative and qualitative characteristics of wheat crop Triticum aestivum L.. Master's thesis. College of Agriculture. Al-Muthanna University. Iraq.
.8 Arnos, Ali Majid Jaber (2022). Response of barley plant to liquid organic fertilizer produced from anaerobic fermentation of poultry waste. Master's thesis, College of Agriculture, University of Basra, Iraq.
.9 Behera, S. K., & Panda, R. K. (2009). Integrated management of irrigation water and fertilizers for wheat crop using field experiments and simulation modeling. Agricultural water management, 96(11,(
.10 Ciofi degli Atti, C., Pace, E. and Salme, G. (2005). γ-Scalino from 3He: Final state interaction, binding effects and three-body forces. In The Three-Body Force in the Three-Nucleon System: Proceedings of the International Symposium Held at The George Washington University Washington, DC, April 24–26, 1986 (pp. 349-355). Berlin, Heidelberg: Springer Berlin Heidelberg.
.11 Hassoun, Ibrahim Khalil (2005) Biological and chemical control of potato stem canker Rhizoctonia solani Kuhn. PhD thesis. College of Agriculture. University of Baghdad.
.12 Kannan, G., O'Kelly, B. C. and Sujatha, E. R. (2023). Geotechnical investigation of low-plasticity organic soil treated with nano-calcium carbonate. Journal of Rock Mechanics and Geotechnical Engineering, 15(2):500-509.
.13
Kapadiya,l.B.;undhad,J.R.;Talaviya,A. and Siddapara,M.R.(2014).Evaluation of phytoextracts against Fusarium solani Causing root rot of okra.J.Biopest.7:7-9 pp.
.14 Kaya YV, Kaya G, Evci I, Şahin M, Ustun Kaya (2008a). The situation and future directions of sunflower production in black sea region. Proceedings of the 17th international sunflower conference, Vol. II, pp 785–790.
.15 Lahuf, A. A., Abdullah, K. M., & Mohammadali, M. T. (2020). Assessment of the nanosized particles of ZnO and MgO and some cultivars in control of Alternaria solani causing tomato early blight. Ecology, Environment and Conservation Journal, 26,

89-95.

.16 Larramendy, M. L. and Soloneski, S. (2019). Organic fertilizers: history, production and applications. BoD–Books on Demand.

.17 Liu, D. Y., Liu, Y. M., Zhang, W., Chen, X. P. and Zou, C. Q. (2019). Zinc uptake, translocation, and remobilization in winter wheat as affected by soil application of Zn fertilizer. Frontiers in Plant Science, 10: 443999 .Nano materials on remediation of polycyclic aromatic hydrocarbons-contaminated soils: a review. Journal of environmental management, 284: 112023 .

.18 Mandal KG, Hati KM, Misra AK (2009) Biomass yield and energy analysis of soybean production in relation to fertilizer-NPK and organic manure. Biomass Bioenergy 33:1670–1679.

.19 Nozawa, T. ; M. Nakajima ; I.Tamai ; K.Noda ; J. I. Nezu ; Y.Sai and T.Yokoi (2002). Genetic polymorphisms of human organic anion transporters OATP-C 120 (SLC21A6) and OATP-B (SLC21A9): allele frequencies in the Japanese population and functional analysis. J. Pharmacol. and Exper. Therap. 302(2) : 804-813.

.20 Othman, Tawfiq, Umaima Nasser, Haitham Eid, and Muhammad Munhal Al-Zaabi (2022). The effect of mineral fertilizer and liquid biogas fertilizer on some vegetative growth and productivity characteristics of peanut crop. Syrian Journal of Agricultural Research. 9 (1): 220-234.

.21 Perin, V., Santos, E.A., Lollato, R., Ruiz Diaz, D.A. and Kluitenberg, G.J. (2020). Impacts of ammonia volatilization from broadcast urea on winter wheat production. Agronomy Journal. 112: 3758-3772.

.22 Rai, M., A.P. Ingle, P. Paralikar, N. Anasane, R. Gade and P. Ingle. 2018. Effective management of soft rot of ginger caused by Pythium spp. and Fusarium spp.: emerging role of nanotechnology. Applied Microbiology and Biotechnology, 102: 6827–6839.

.23 Robertsan ,M.J.,and Giunta , F.1994.Responses of speing wheat exposed to pre anthesis water stress .Aust.J.Agric.Res.45:19-45.

.24 Seesanong, S., Seangarun, C., Boonchom, B., Laohavisuti, N., Chaiseeda, K. and Boonmee, W. (2021). Composition and properties of triple superphosphate obtained from oyster shells and various concentrations of phosphoric acid. ACS omega, 6(34), 22065-22072.

.25 Singh, P.K. , Kumar, V. (2011). Variability among isolates of Fusarium oxysporum f.sp. chrysanthemi pathogenic to Chrysanthemum. Inter. J. Plant Pathol., 2(3): 136-143.

.26 Tarafdar JC, Raliya R, Mahawar H, Rathore I (2014) Development of zinc nanofertilizer to enhance crop production in pearl millet (Pennisetum americanum). Agric Res 3:257–262.

.27 Wilkie, A. C. (2005). Anaerobic digestion: biology and benefits. Dairy manure management: treatment, handling, and community relations, 63-72.

.28 Xu, R., Rai, A., Chen, M., Suwakulsiri, W., Greening, D. W. and Simpson, R. J. (2018). Extracellular vesicles in cancer-implications for future improvements in cancer care. Nature reviews Clinical oncology, 15(10):617-638.

.29 Zhaoxiang, W., Huihu, L., Qiaoli, L., Changyan, Y. and Faxin, Y. (2020). Application of bio-organic fertilizer, not biochar, in degraded red soil improves soil nutrients and plant growth. Rhizosphere, 16, 100264 .

.30

ISSN 2072-3857