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Effect of Poultry Manure in Interaction with Mycorrhizae and Nano-Phosphate Rock on the Growth and Yield of Cucumber

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ABSTRACT

A field experiment was conducted in Iraq - Al-Qadisiyah Governorate - Afak- Al-Thuraimah for cucumber crop in The autumn season of 2024 .The aim of studying the effect of three factors .The first factor is the fungal biological *Glomas mossae* at two levels (without Inoculation , with Inoculation). The second factor is three levels of nanoparticles of phosphate rock (without add , 20 and 40) kg.ha^{-1}. The third factor is three levels of composed poultry manure (2, 3, and 4) t. ha^{-1}. The treatments in the factorial experiment were distributed according to a completely randomized block design. Bioinoculation with mycorrhizal and the addition of nanoparticles and mono Poultry Manure , as well as the double interaction B_1*O (mycorrhiza inoculation and Poultry Manure), B_1*Rn (mycorrhiza inoculation + nanoparticle), and O*Rn (nanoparticles + Poultry Manure). It had a significant effect on increasing plant height (cm), leaves nitrogen content % in a period of (35) days, early yield, and total yield (kg. plastic greenhouse $^{-1}$). The highest increase in these properties was in the triple interaction study (B_1*Rn*O mycorrhiza inoculation + nanoparticles + organic material). Which amount to 198.91 (cm), 5.74 (%), 699 and 3720 (kg. plastic greenhouse^{-1}) respectively, compared with the control treatment, which gave the lowest averages of 174.31 (cm), 3.95 (%), 571 and 2800 (kg. plastic greenhouse^{-1}). This indicates the important role of the fungal bioinoculation in interacting with

phosphate rock nanoparticles and composed poultry manure in increasing the growth and production of Cucumber crop.

Keywords: ***Phosphate rock nanoparticles*****، *Glomas mosseae*, poultry manure and Cucumber**

Introduction

International organizations consistently call for a 50% increase in food production to meet the growing global population needs by 2025, the increase in food quantities comes from increasing crop production in sufficient quantities , by using new technologies that improve plant nutrition processes **[19 , 26].**Phosphate rock nanoparticles are among these important technologies , the use of fungal biofertilizers such as *Glomus mosseae* is an important step sustainable agriculture **[1 , 8 , 16] .** Organic matter is of great importance to soil health, plant nutrition and soil microbial **[5 , 23].**This is reflected in plant production and improving the quality of production**[20 , 23].** The results of the field experiment showed for the cucumber crop in the greenhouse for the autumn season of 2018, Biofertilization with the fungus *Glomus mosseae* achieved a significant increase in the following indicator of the cucumber crop (plant height, leaves area, total dry root weight, number of flowers per plant, early and total yield), The values of the treatments were 186 (cm.plant^{-1}), 3775.53 (cm^{2}.plant^{-1}), 0.71 (g.plant^{-1}), 89.75 (flower.plant^{-1}), 632.23 and 3265.46 (kg.greenhouse^{-1}). Compared to the control 76183 (cm.plant^{-1}), 3336.34 (cm^{2}.plant^{-1}), 0.61 (g.plant^{-1}), 87.37 (flower.plant^{-1}), 608.85 and 2884.42 (kg.greenhouse^{-1}), Because of the role of mycorrhizal fungi in increasing nutrients and improving water relations in the plant, this led to the accumulation of nutrients and a significant increase in the studied indicator **[5 , 17]**.The results of a study on the effect of adding nanoparticles to the nutrient solution for growing cucumber crops in the (Hydoponics) system, showed that there was a significant increase in the values of (chlorophyll, plant dry weight, root dry weight, root length and leaf content of total phosphorus%),the significant difference was (25, 2, 5, 20 and 10)% respectively, compared to the control **[7 , 19].**Cucumber plants inoculated with mycorrhizae are characterized by their ability to increase the absorption of nitrogen, phosphorus and potassium, which is reflected in an increase in the dry weight plant. Increased vitamin C, antioxidants, leaf area and number of flowers because to the creation of additional food pathways for the plant **[20 , 14]** .Also fungus *Glomus mosseae* share in the creation of these new pathways**[22]** This study encourages the use of sustainable agriculture and the Benefit of natural materials found in the local environment, such as phosphate rock nanoparticles, organic poultry manure, and biofertilizers, to preserve the ecosystem and reducing production costs.

Materials and Methods

Nanoparticles of Phosphate Rock and Organic Fertilizer.

The nanoparticles were prepared from natural phosphate rock found in the Akashat of western Iraq using a mechanical method in two stages: first, Jet milling, then Ball milling, for a period of 72 hours. The particles were confirmed to be within the required range of 40-100 nanometers using(SEM) Scanning Electron Microscopy **[26 , 12].** *G. mosseae* inoculum was obtained from the Biotechnology Laboratory, Agricultural Research Office , Ministry of Science and Technology, and consisted of spores loaded on peatmoss at a rate of 100 spores g^{-1}. composed poultry manure was used in the field experiment on cucumber crops.

Factors and Experimental Design

The first factor: *G.mosseae* at two levels, addition and non-addition (G_1 and G_2). The second factor: Poultry Manure, which is composed poultry manure (O), three different levels (O1, O2, O3) which are (2, 3 and 4) t. h^{-1}. The third factor: Phosphate rock nanoparticles (Rn) at three different levels (Rn_1, Rn_2, Rn_3), which are (0, 20, and 40) kg.ha^{-1} . The factorial experiment was carried out with an (R.C.B.D) design and statistically analyzed using the GenStat program. The means were compared using the least significant difference (L.S.D) at a probability level of 0.05% to determine the type of significance between the means of the different treatments.

Field experiment

The field experiment was carried out in Al-Qadisiyah – Afak – Al-Thuraimah. After plowing, and leveling, the soil of the greenhouse was divided into experimental units with dimensions of 2*3m^2, totaling 18 experimental units distributed randomly across three replicates. Isolation spaces were left between the replicates and the experimental units. The cucumber crop was planted on 13/10/2023 with a spacing of 25 cm between plant and other plant, the number of plants in each experimental unit was 8 on one side of the experimental unit. Phosphate rock particles were added(3)cm around the seeds, according to the experimental design. Crop service operations were carried out, and a quarter of the recommended fertilizer amount for phosphorus and a full recommendation for nitrogen and potassium were added according to the recommendations of the Iraqi Ministry of Agriculture.

The N % content of the leaves was estimated at(35) days after germination.

The fourth leaves was taken from below of the growing tip, digested, and the nitrogen was estimated using Kjeldahl and titration, as reported in **[3].**

Field measurements

The plant height (cm) was measured with a measuring tape. The early yield of the greenhouse (kg) was the first three harvests per experimental unit, and the following equation was calculated: Early yield of one experimental unit / Number of plants in it × Number of plants in the greenhouse. As for the total yield of the greenhouse (kg), it was calculated according to the following equation: Productivity of one experimental unit / Number of plants in it × Total number of plants in the greenhouse.

Results of the field experiment

Tables: (1, 2, 3 and 4) showed that fungal biofertilization with *Glomus mosseae* fungus alone and the addition of Poultry Manure alone also and Addition nanoparticles alone gave a significant increase in plant height (cm) and leaf nitrogen content % in a period of (35) days, early yield and total yield (kg.$greenhouse^{-1}$). The bioinoculation treatment (B_1) with the *Glomus mosseae* fungus resulted in a significant increase in plant height, 198.91 (cm) compared to the control 185.73 (cm). The treatment gave a significant increase in early yield, 668 (kg. plastic $greenhouse^{-1}$) compared to the control 583 (kg. plastic greenhouse $^{-1}$). The treatment gave a significant increase in the total yield, 3268 (kg.greenhouse^{-1}) compared to the control 2972 (kg.greenhouse^{-1}). The bioinculation treatment achieved a significant increase in the nitrogen content of the leaves, 5.83% compared to the control of 4.2.1%.

The addition of (Rn) nanoparticles also resulted in a significant increase in plant height 188.41 (cm) compared to the control 164.55 (cm). The treatment gave a significant increase in early yield, 676 (kg. plastic greenhouse $^{-1}$) compared to the control of 583 (kg. plastic greenhouse $^{-1}$). The treatment resulted in a significant increase in total yield 3268 (kg.greenhouse^{-1}) compared to the control 2972 kg.greenhouse^{-1}. The treatment also achieved a significant increase in leaf nitrogen content, 5.53% compared to the control 4.17%.

The addition of composed poultry manure (O) resulted in a significant increase in plant height, 193.13(cm) compared to the control 185.32 cm. This treatment also significantly increased early yield, 583 kg.greenhouse^{-1} compared to the control 575 kg.greenhouse^{-1}. The same treatment significantly increased total yield, reaching 3263 kg.greenhouse^{-1} compared to the control 2813 kg.greenhouse^{-1}. The treatment also achieved a significant increase in the nitrogen content %of the leaves, 5.74% compared to the control 4.16%.

As shown in Tables (1, 2, 3 and 4) the double interactions of the study factors (B_1*O) and (B_1*Rn), (O * Rn) gave a significant increase in plant height (cm), leaves nitrogen content %, early yield and total yield (kg.greenhouse^{-1}).

The double (B_1*O) interaction (mycorrhizal + Poultry Manure) led to the highest significant increase in plant height, 194.51 (cm) compared to the control of 179.41 (cm). The treatment also gave a significant increase in early yield, 679 (kg. plastic greenhouse $^{-1}$) compared to the control of 579 (kg. plastic greenhouse $^{-1}$). The treatment also gave a significant increase in the total yield, 3474 (kg.greenhouse^{-1}) compared to the control treatment 2815 (kg.greenhouse^{-1}). The treatment also achieved a significant increase in the nitrogen content% in the leaves, 5.85% compared to the control 4.15%.

The interaction of (B_1*Rn) (mycorrhizal + nanoparticles) resulted in a significant increase in plant height 196.83 (cm) compared to the control (147.53 cm). This treatment also significantly increased early yield, 693 (kg.greenhouse^{-1}) compared to the control 581(kg.greenhouse^{-1}). The treatment significantly increased total yield, 3673 kg.greenhouse^{-1} compared to the control 2830 (kg.greenhouse^{-1}). this treatment significantly increased leaves nitrogen content 5.70% compared to the control (4.10%).

The double (O*Rn) interaction (nanoparticles + Poultry Manure) led to a significant increase in plant height, 620 (cm) compared to the control treatment of 578 (cm). The treatment also gave a significant increase in early yield of 585 (kg.greenhouse^{-1}) compared to the control treatment of 578 (kg.greenhouse^{-1}). The treatment also gave a significant increase in the total yield, 3221 (kg.greenhouse^{-1}) compared to the control which 2807 (kg.greenhouse^{-1}). The treatment also achieved a significant increase in the nitrogen content% in the leaves 5.82% compared to the control 4.09%.

Tables(1, 2, 3 and 4) showed that the triple interaction of the study factors (B1*Rn*O) led to the highest significant increase in the field experiment for plant height (cm), leaves nitrogen content %, early yield and total yield (kg.greenhouse^{-1}). The triple interaction (B1*Rn*O) (bioinoculation with mycorrhizae + nanoparticles + organic matter) gave the highest significant increase in plant height 198.91 (cm) compared to the control 174.31 (cm). The treatment resulted in the highest significant increase in early yield 699 (kg.greenhouse^{-1}) compared to the control 571 kg.greenhouse-^{1}. It also resulted in the highest significant increase in total yield 3720 (kg.greenhouse^{-1}) compared to the control 2800 (kg.greenhouse^{-1}). The triple interaction treatment achieved the highest significant increase in leaves nitrogen content 3.95% compared to the control (5.74%).

Effect of Fertilization with Mycorrhizal Fungus in Interaction with Phosphate Rock Nanoparticles and Poultry Manure on Plant Height (cm)

Table(1). Effect of fertilization with mycorrhizal fungus in intracation with phosphate rock nanoparticles and Poultry Manure on plant height (cm).

Biofertilizer (B)	Nanoparticle levels Rn kg.ha^{-1}	Poultry Manure levels (O) T.ha^{-1}			Mine B*Rn
		2	3	4	
Inoculation without B_0	0	174.31	174.53	177.11	147.53
	20	181.21	184.93	180.31	178.33
	40	182.51	184.53	185.34	183.53
Inoculation B_1	0	187.32	187.84	188.91	187.75
	20	187.34	180.41	183.52	196.83
	40	196.91	195.3	198.32	196.94
$_{B*O*Rn}$ 4.104 Lsd=					Lsd= $_{B*Rn}$ 2.941
Intraction B*O		179.41	183.83	184.01	Mine B=
		194.51	189.85	184.61	185.73
Lsd B*O =2.859					198.91
Intraction O*Rn	0	188.34	188.47	198.56	Lsd $_B$ =3.66
	20	189.39	190.34	191.34	Lsd O*Rn =2.762
	40	198.35	199.56	200.11	
Mine O		185.32	186.71	193.13	Lsd O=1.627
Mine Rn		174.55	183.01	188.41	Lsd Rn=1.5 27

Table (2). Effect of fertilization with mycorrhizal fungi in interaction with phosphate rock nanoparticles and Poultry Manure on early yield (kg.greenhouse^{-1})

Biofertilizer (B)	Nanoparticle levels Rn kg.ha^{-1}	Poultry Manure levels (O) T.ha^{-1}			Mine B*Rn
		2	3	4	
Inoculation without B_0	0	571	573	576	581
	20	579	595	620	598
	40	630	641	648	630
Inoculation B_1	0	653	658	660	772
	20	668	672	679	673

	40	685	699	693	693
$_{B*O*\ Rn\ 5.040}$ Lsd=					Lsd= $_{B*Rn}$ 3.397
Intraction B*O		579	603	614	Mine B
		668	675	679	583
Lsd B*O =2.916					679
Intraction O*Rn	0	578	580	581	Lsd $_B$ =3.29
	20	583	588	590	Lsd O*Rn =3.665
	40	593	595	620	
Mine O		577	580	583	Lsd O=2.017
Mine Rn		575	583	585	Lsd Rn=2.62

Table (3). Effect of fertilization with mycorrhizal fungi in interaction with phosphate rock nanoparticles and Poultry Manure on the nitrogen content of the leaves at (35) days of planted .

Biofertilizer (B)	Nanoparticle levels Rn kg.ha^{-1}	Poultry Manure levels (O) t.ha^{-1}			Mine B*Rn
		2	3	4	
Inoculation without B_0	0	3.95	4.11	4.15	4.10
	20	4.17	5.25	5.38	4.20
	40	5.40	5.48	5.51	4.53
Inoculation B_1	0	5.53	5.58	5.61	5.38
	20	5.63	5.67	5.67	5.65
	40	5.70	5.77	5.74	5.70
$_{B*O*\ Rn}$ 0.2877 Lsd=					Lsd= $_{B*Rn}$0.281
Intraction B*O		4.15	4.27	4.33	Mine B
		5.60	5.71	5.85	4.21
Lsd B*O =0.2801					5.83
Intraction O*Rn	0	4.09	4.20	4.39	Lsd $_B$ =0.3231
	20	5.53	5.68	5.71	Lsd O*Rn =0.1913
	40	5.78	5.80	5.82	
Mine O		4.16	5.32	5.73	Lsd O=0.193
Mine Rn		4.17	5.30	5.53	Lsd Rn=0.2036

Table (4). Effect of fertilization with mycorrhizal fungi in interaction with phosphate rock nanoparticles and Poultry Manure on total yield (kg. greenhouse $^{-1}$).

Biofertilizer (B)	Nanoparticle levels Rn kg.ha^{-1}	Poultry Manure levels (O) T.ha^{-1}			Mine B*Rn
		2	3	4	
Inoculation without B_0	0	2800	2843	2855	2830
	20	2871	3000	3037	2873
	40	3067	3072	3076	3070
Inoculation B_1	0	3080	3110	3179	3155
	20	3261	3283	3360	3280
	40	3420	3713	3720	3673
$_{B*O*\ Rn}$ 49.22 Lsd=					Lsd= $_{B*Rn}$ 50.95
Intraction B*O		2815	2908	3001	Mine B
		3120	3253	3474	2972
Lsd B*O =55.37					3268
Intraction O*Rn	0	2807	2830	2856	Lsd $_B$ =64.82
	20	2870	2895	3123	Lsd O*Rn =22.44
	40	3165	3187	3221	
Mine O		2813	2014	3263	Lsd O=10.65
Mine Rn		2803	2854	3114	Lsd Rn=18.41

Discussion

The mycorrhizal fungus *Glomus mosseae* plays an important role in increasing the availability of nutrients in the soil, including nitrogen and phosphorus, and improving water relations in the plant, which led to the accumulation of nutrients that was reflected in the increase of the studied indicators in the cucumber plant, including plant height, early yield, and total yield [4 , 5 , 28]. Poultry Manure is rich in different nutrients, enzymes and microorganisms, thus improving the plant root environment and improving the chemical, physical and biological properties of the soil [13 , 6].*Glomus mosseae* fungi, during their life cycle, secrete enzymes such as phytase and phosphatase, which increase soluble phosphorus in poor soils and help dissolve apatite by breaking down ester bonds that link phosphate to carbon[15 , 24]. The interaction between mycorrhizal fungi and nanoparticles is very important for the plant, as the fungi increase the availability of phosphorus by secreting many organic acids that make the medium more acidic, thus increasing the availability of phosphorus from nanoparticles, as well as secreting phosphatase enzymes responsible for converting phosphorus into the available form, in addition to the ability of the fungi to absorb water and nutrients from the of the rhizosphere plant and transport them quickly to the plant,The significant increase in the study indicators when nanoparticles are added is due to the dissolution of these particles in the cucumber plant's rhizosphere by the biological community, which is reflected in the accumulation of nutrients in the plant and thus increased growth [9 , 10]. The fungus *G. mosseae* is characterized by its ability to dissolve Poultry Manure and increase the availability of nutrients, especially nitrogen, phosphorus, zinc, and others. Poultry Manure plays a role in maintaining a good level of moisture, different nutrients to move with the water mass, which is reflected in different plant growth indicators[11 , 12 , 18]. The organic matter and the organic acids it contains increase the decomposition of phosphorus compounds, which are important in the development of the root system and the building of a root system that helps the plant to grow and produce [2 , 25].The productivity of the greenhouse in the early and total yield in the triple interaction was greater than the productivity of the greenhouse in the double interaction. From an economic point of view, the second level of organic matter (3 t. ha^{-1}) was better than the second level (t. ha^{-1}) in the early and total yield of cucumbers in the greenhouse.

Conclusions

Based on field and laboratory results, it was found that the triple interaction between fungal inoculant, phosphate rock nanoparticles, and Poultry Manure led to an increase in cucumber plant height, leaves nitrogen% content, early and total yield. The triple interaction treatment (B_1+Rn_{40}+O_3) gave the highest significant increase in plant height, early yield and total yield (20, 22, 36 and 46%) respectively, compared to the control.

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