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Effect of Adding NPK-Chitosan Fertilizer and Organic Matter on phosphorus and potassium content of Corn (*Zea mays* L.)

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Abstract

A field experiment was conducted at the College of Agriculture, University of Basrah's research station in Garmat Ali during 2022 agricultural season. The study aimed to investigate the impact of three types of fertilizers (commercial NPK as a control and two types of prepared NPK-Chitosan organic fertilizers) at four addition levels (0, 1, 1.5, and 2 ton ha^{-1}) and two levels of organic matter (0% and 2.5%) on the availability of nitrogen and potassium in loam sandy soil and yield of corn (*Zea mays* L.).

The results indicated a significant effect of fertilizer type on increasing Phosphorus and Potassium Content of corn plant. The highest values of Phosphorus and Potassium Content for corn were 6.15 and 47.07 gm kg^{-1} respectively for the added fertilizer type. The NPK-Chitosan fertilizer in a 1:3 coating ratio achieved the, 3.62 and 31.01 kg ha^{-1}, respectively, followed by the treatment of NPK-Chitosan fertilizer with a 1:3 mixing ratio and a fertilizer level of 2 tons/ha, which yielded The results showed a significant effect of fertilizer level on increasing Phosphorus and Potassium Content of the corn plants. Phosphorus and Potassium Content increased with higher levels of added fertilizer. The level 2 achieved the highest values of Phosphorus and Potassium Content for the vegetative part corn plants, reaching 2 tons per hectare.4.22 and 37.91 gm kg^{-1}, and with a significant difference from level 1 and 1.5 tons per hectare, level 2 also outperformed level 0 tons per hectare (the control treatment). Similarly, the organic matter showed a significant effect the results indicated a significant interaction between the type and level of fertilizer, as well as the level of added organic matter to the soil, on Phosphorus and Potassium Content of the yellow corn plants. The NPK-Chitosan fertilizer with a 1:3 coating ratio added at the level of 2 tons per hectare outperformed the other treatments, yielding the highest phosphour contentand grain yield.

Keywords: NPK-Chitosan fertilizer, Corn, shoots, Content

I. INTRODUCTION

Chitosan is a straight-chain natural polymer with polymer chain units ranging from 2000 to 3000. It is one of the most abundant polymers of multiple sugar units in nature. The molecular weight of chitosan varies from 100,000 to 1,200,000 daltons, depending on the method of preparation (Chang *et al*., 2011). It is the second most widely distributed organic compound after cellulose in nature, with a molecular formula of $(C_6H_{11}O_4N)n$. Chitosan is extracted from various natural sources and constitutes about 20-30% of the waste and shells of crustaceans, such as shrimp, crab, lobster, and crayfish (Dash *et al*., 2011). Chitosan is obtained by removing acetyl groups from chitin, which contains (60-100)% N-acetyl-glucosamine in the polymer chain. The importance of polymeric materials in the manufacture of slow-release fertilizers

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includes natural polymeric materials such as chitosan, which can be used with mineral fertilizers containing nitrogen, phosphorus, and potassium. Abdel-Aziz et al.(2016) found the Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. The objective of the present study was to examine the effects of chitosan-NPK application on growth and productivity responses of corn plants grown on loamy clay soil.

II. MATERIALS AND METHODS

The field experiment was conducted at the research station affiliated with the College of Agriculture, University of Basrah, Garmat Ali site. Physical and chemical properties of filed soil were determined according to the methods mentioned in Page et *al*.1982 and Black,1962,(table 1). The experiment included the following treatments three types of fertilizer (commercial NPK as control and two types of NPK-Chitosan (NPK mixing and coating with chitosan), at four levels (0, 1, 1.5, and 2 ton ha^{-1}). Organic matter was added at two levels (0% and 2.5%) with three replicated resulting in a total of 72 experimental. Corn crop (*Zea mays* L.) variety Sagunto was sown during the agricultural season on March 18, 2022, with a spacing of 40 cm between rows and 5 seeds per hill. Plants were cut off at 28/6/2022 within 1 cm of soil surface, and washed with tap water firstly and then with distilled water ,then dried in an oven at 65° c until the weight stabilize . Dry wegh of shoot was recorded.
TOTAL Grain yield of corn crop was recorded at 28/6/2022 from grain of four plants according to the relationship below:-

Table 1: Chemical and Physical Properties of Field Experiment Soil.

Properties		Value	Units
pH(1:1)		7.78	-
Electrical Conductivity (EC)(1:1)		3.55	$dS.m^{-1}$
Cation Exchange Capacity (CEC)		11.34	$cmol.kg^{-1}$
Organic Matter		5.69	$g.kg^{-1}$
Carbonate Minerals		259	$g.kg^{-1}$ soil
Available Nitrogen		9.58	mg kg^{-1}
Available Phosphorus		10.36	
Available Potassium		33.29	
Soluble Cations	Ca^{+2}	10.47	Mmol L^{-1}
	Mg^{+2}	7.61	
	Na^{+}	11.98	
	K^{+}	8.63	
Soluble Anions	Cl^{-}	15.76	Mmol L^{-1}
	SO_4^{-2}	10.46	
	HCO_3^{-}	8.25	
	CO_3^{-2}	0.00	
Soil Fractions	Clay	128.50	G kg^{-1}
	Silt	305.30	
	Sand	565.80	
	Soil Texture		Loam Sandy

Results and Discussion:

Phosphorus Content

The results presented in table 2 indicate that type of fertilizer had a significant effect on phosphour content of shoot of corn plant. NPK fertilizer coated with chitosan (NPK-chitosan) at 1:3 ratio showed a significant superiority over other fertilizers

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Table 2: Effect of type and level of fertilizer (ton ha^{-1}) and organic matter (%) on phosphour content of shoot of corn crop

Fertilizer Type	Organic Matter (%)	Fertilizer Concentration (ton h^{-1}) NPK-Chitosan				Organic × Fertilizer Type Matter
		0	1	1.5	2	
Coated 1:3	0	0.40	2.75	4.17	5.95	3.32
	2.5	0.53	3.53	5.47	6.15	3.92
Mixing 1:3	0	0.40	2.07	2.61	3.18	2.07
	2.5	0.53	2.42	3.26	4.08	2.57
NPK	0	0.40	1.22	1.97	2.85	1.61
	2.5	0.53	1.59	2.84	3.12	2.02
RLSD		0.1322**				0.0661**
Fertilizer Type×Fertilizer level		0	1	1.5	2	Fertilizer Type
Coated 1:3		0.47	3.14	4.82	6.05	3.62
Mixing 1:3		0.47	2.52	2.94	3.63	2.29
NPK		0.47	1.41	2.41	2.99	1.81
RLSD		0.0935**				0.0467**
Fertilizer level × Organic Matter		0	1	1.5	2	Organic Matter
Organic Matter(0%)		0.40	2.01	2.92	3.99	2.33
Organic Matter (2.5 %)		0.53	2.45	3.86	4.45	2.82
R.LSD		0.0763**				0.0381**
Fertilizer level		0.47	2.26	3.39	4.22	
RLSD		0.0540**				

NPK: (465 ppm N, 200 ppm P, 380 ppm K)

It was followed by the NPK fertilizer mixed with chitosan at a 1:3 ratio, which yielded an average of 3.62 gm kg^{-1}. These two treatments significantly outperformed the NPK fertilizer (control), which recorded an average of 1.81 gm kg^{-1}, with an increasing percentage of 50.00% .The variation in the fertilizers' effects on the phosphour contentof shoot can be attributed to the differences in their chemical composition and general characteristics. Fertilizers containing chitosan enhance the nutrient absorption rates by the plant and improve the availability in soil. They also encourage the development of a root system. Additionally, chitosan activates soil microorganisms as it serves as a source of essential nutrients for their growth. All these factors contribute to the overall growth, yield, and phosphour contentof shoot compared to NPK fertilizer(control), which aligns with previous findings Malerba and Cerana (2016) و Behboudi *et al.,*(2018) and Vince *et al.,*(2019).

Results in table 2 indicate a significant effect of the added fertilizer level on the phosphour content of treatments with fertilizer levels (1, 1.5, and 2 ton h^{-1}) outperformed the control treatment, with phosphour contentvalues of 2.26, 3.39and 4.22 gm kg^{-1} for the levels of 0 tons h^{-1},(0.47 gm kg^{-1}) respectively. The highest percentage increase was observed at the level 2 tons h^{-1} ,reaching 88.86 % comparing with control , followed by 1.5 ton h^{-1} level, which showed a 79.21% increase compared to the control treatment.

Table 2 demonstrates the effect of organic matter level on phosphour content of corn crop. The control treatment (without any addition) yielded the lowest average phosphour contentof shoot 2.33 gm kg^{-1},while 2.5 ton ha^{-1} level resulted the highest average phosphour contentof shoot 2.82 gm kg^{-1}, with a percentage increase of 17.43% compared to control treatment. It indicates that organic matter caused increase in phosphour contentof shoot because its rile in an improving the physical and chemical properties of soil and increasing nutrient availability which significantly affects plant growth. It is agree with the findings of Shalash (2020), who observed that organic fertilizer resulted in the highest increase in phosphour contentof corn plants grown in clayey and loam sandysoils..

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Results in table 2 demonstrate a significant interaction between fertilizer type and the level of organic matter on the phosphour content of plant corn. It is evident that a significant increase in phosphour content of shoot was observed for the treatment with chitosan-coated NPK fertilizer at a ratio of 1:3 and NPK fertilizer mixed with chitosan at a ratio of 1:3, compared to NPK fertilizer alone. The variation between fertilizers increased with the level of organic matter addition, and the highest significant differences appeared at 2.5 ton.ha^{-1} level of organic matter . At this level, the chitosan-coated NPK fertilizer at a ratio of 1:3 and NPK fertilizer mixed with chitosan at a ratio of 1:3 outperformed the other treatments, with phosphour content of shoots values of 3.92 and 2.57 gm kg^{-1}, respectively .In contrast, the NPK fertilizer with organic matter at 2.5ton h^{-1} level yielded a phosphour contentof shoot value of 1.61 gm kg^{-1}. It indicates that the combination of chitosan-coated NPK fertilizer with the 2.5 ton ha $^{-1}$ level of organic matter had a superior effect on the phosphour content of shoot compared to the other treatments. It can be attributed to the role of slow-release fertilizers in an increasing nutrient availability in the soil during plant growth stages, which encourages strong root development and, consequently, promotes plant growth. Additionally, organic matter improves soil properties and nutrient availability, and chitosan further enhances nutrient availability and soil moisture content. These results were agree with previous findings of Agbodjalo *et al(*2016) .

Results in table 2 demonstrate a significant interaction between type and level of fertilizer in an increasing of phosphour content of corn crop. NPK fertilizer treatment at level 0 kg ha^{-1} (control) yielded the lowest phosphour contentof shoot 0.47, in contrast, chitosan-coated NPK fertilizer at a ratio of 1:3 and at level 2 kg ha^{-1} level of fertilizer resulted the highest phosphour content of shoot 6.05 gm kg^{-1}, with significant differences compared to the other treatments and a percentage increase of 92.23% compared to the NPK fertilizer treatment at 0 kg ha^{-1} level. These results were agree with the results of Shao *et al.* (2005) and Cho *et al*. (2008).

The interaction between the level of organic matter and level of fertilizer significantly affected the phosphour content shoot of corn crops (table 2). Control treatment yielded the lowest phosphour content of shoot 0.40 gm kg^{-1}. The treatment at the 2.5 ton ha^{-1} level of organic matter and 2 kg ha^{-1} fertilizer level resulted the highest phosphour contentof shoot 4.45 gm kg^{-1}, with significant differences compared to the other treatments.

Table 2 indicate that the triple interaction between type of fertilizer, fertilizer level and organic matter level had a significant effect on increasing of phosphour content of shoot of corn crop . The chitosan-coated NPK fertilizer at ratio of 1:3 and fertilizer level at 2 kg ha^{-1} and organic matter at level of 2.5 ton ha^{-1} yielded the highest phosphour content of shoot reached to 6.15 gm kg^{-1}. It was followed by the chitosan-coated NPK fertilizer at a ratio of 1:3 at 2 kg ha^{-1} fertilizer level and 0 ton ha^{-1} organic matter level, as well as the NPK fertilizer mixed with chitosan at a ratio of 1:3 at the 2 kg ha^{-1} fertilizer level and 2.5 ton.ha^{-1} organic matter level, with phosphour content of shoot 4.08 gm kg^{-1}. It demonstrates the role of chitosan in an increasing of phosphour contentof shoot of corn crop and the necessity of its use to enhance the availability of essential nutrients for plant growth, resulting an increase of phosphour contentof shoot of corn plants. These results were agreed with the results of Mondal *et al*. (2012).

Potassium Content

Results in table 3 show that type of fertilizer had a significant effect on increasing of potassium content of corn. The chitosan-coated NPK fertilizer at a ratio of 1:3 significantly outperformed the other fertilizers, with an average yield of 31.01 gm kg^{-1}. It was followed by NPK fertilizer mixed with chitosan at a ratio of 1:3, which yielded an potassium content average of 28.31 gm kg^{-1}. Both treatments were significantly higher than NPK fertilizer, which recorded an average yield of 22.81 gm kg^{-1}, with percentage increases of 26.44% and 19.42%, respectively. This increase can be attributed to the soil's enhanced availability of nitrogen, phosphorus, and potassium. The variation in yield quantity among the fertilizer types can be attributed to differences in composition and characteristics of each fertilizer.

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Fertilizers containing chitosan contribute to increased nutrient availability, nutrient absorption by plants, improved soil moisture content, and promotion of extensive root system development. Additionally, chitosan activates microbial soil organisms are considered a source of essential nutrients for plant growth, affecting plant development, yield, and dry weight, it consistent with the findings of Malerba and Cerana (2016), who observed that adding chitosan to the soil regulated biological activities and promoted good root and shoot growth. It also increased nutrient absorption and enhanced photosynthetic processes and nutrient storage (carbohydrates and proteins), ultimately impacting grain yield.

Results in table 3 indicated a significant effect of fertilizer level on total potassium content of corn plant. All treatments with added fertilizer outperformed the control treatment, with the potassium content values for the fertilizer levels of 1, 1.5, and 2 kg ha^{-1} reaching 26.53, 32.80, and 37.91 gm kg^{-1}, respectively. The treatment without added fertilizer (0 kg ha^{-1}) had a grain yield of 12.23 mg kg^{-1}. The highest percentage increase was observed at 2 kg ha^{-1} fertilizer level compared to the treatment without any addition (0 kg ha^{-1}), followed by 1.5 kg ha^{-1} fertilizer level and then the 1 $kg.h^{-1}$ fertilizer level .Moreover, the 2 kg ha^{-1} level outperformed the 1.5 $kg.h^{-1}$ concentration with percentage increases of 47.99%, 62.71%, 67.73%, respectively compared to control treatment. These findings agreed with Abdel-Aziz *et al.* (2018), who observed a similar increase in grain yield when chitosan was mixed with different levels of NPK fertilizer.

Table 3 illustrates the effect of organic matter level on the potassium content of corn. The treatment with an organic matter level of 2.5 tons ha^{-1} produced the highest potassium content, reaching 29.51 gm kg^{-1}, with a percentage increase of 14.51% compared to control treatment (0 ton ha^{-1}). It indicates that organic matter contributed to an increase in total grain yield of corn crop. On the other hand, control treatment without any addition yielded the lowest rate of potassium content at 25.23gm kg^{-1}. It could be attributed to the role of organic matter in an improving of soil chemical, physical and biological properties and increasing its nutrient availability, which significantly impacted plant growth and grain yield. This finding was consistent with the research conducted by Nyiraneza (2009), who observed that the addition of animal waste (cattle) at a level of 20 tons ha^{-1} resulted in an increased yield of corn in clay soil, where the yield increased from 3.9 tons ha^{-1} in the control treatment to 7.9 tons ha^{-1} in the treatment fertilized with animal manure.

The results of Table 3 indicate a significant interaction effect between type of fertilizer and level of organic matter on the potassium content of corn. A significant increase was observed in the treatment of NPK fertilizer coated with chitosan at a ratio of 1:3 and NPK fertilizer mixed with chitosan at a ratio of 1:3 compared to NPK fertilizer. The effects varied depending on the level of organic matter addition, and the variation between fertilizers increased with higher addition levels. The highest significant variations appeared at the 2.5 tons ha^{-1} of organic matter addition. At this level, the NPK fertilizer coated with chitosan at a ratio of 1:3 outperformed the other treatments, with a total potassium content of 33.25 gm kg^{-1}, followed by the NPK fertilizer mixed with chitosan at a ratio of 1:3 with a total grain yield of 30.75 gm kg^{-1}. These values represent percentage increases of 13.51% and 15.86%, respectively, compared to the control treatment with a potassium content of 21.06 gm kg^{-1}. The superiority of the treatment with NPK fertilizer coated with chitosan at a ratio of 1:3 and 2.5 tons ha^{-1} of organic matter addition in terms of grain yield compared to the other treatments can be attributed to the role of slow-release fertilizers in an increasing the availability of nutrients in the soil during plant growth stages. This encouraged the plant to develop a strong root system, which in turn reflected in plant growth and an increase in the number of leaves through phosphour contentin the plant. Additionally, the role of organic matter improving soil properties and nutrient availability, along with the presence of chitosan, which enhances nutrient availability and**.**

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Table 3: Effect of type and level of fertilizer (ton ha^{-1})and organic matter (%) on potassium content **of corn crop (Mg ha^{-1}).**

Fertilizer Type	Organic Matter (%)	Fertilizer Concentration (kg ha^{-1}) NPK-Chitosan				Organic × Fertilizer Type Matter
		0	1	1.5	2	
Coated 1:3	0	11.65	27.31	34.83	41.23	28.76
	2.5	12.80	32.46	40.65	47.07	33.25
Mixing 1:3	0	11.65	24.53	30.63	36.67	25.87
	2.5	12.80	28.63	37.46	44.09	30.75
NPK	0	11.65	21.49	24.72	26.36	21.06
	2.5	12.80	24.74	28.56	32.09	24.55
RLSD		0.161**				0.081**
×Fertilizer level Fertilizer Type		0	1	1.5	2	Fertilizer Type
Coated 1:3		12.23	29.89	37.74	44.15	31.01
Mixing 1:3		12.23	26.58	34.05	40.38	28.31
NPK		12.23	23.12	26.64	29.23	22.81
R LSD		0/114**				0.057**
× Organic Matter Fertilizer level		0	1	1.5	2	Organic Matter
Organic Matter (0 %)		11.65	24.44	30.06	34.57	25.23
Organic Matter (2.5 %)		12.80	28.61	35.56	41.08	29.51
RLSD		0.093**				0.047**
Fertilizer level		12.23	26.53	32.80	37.91	
RLSD		0.066OO				

NPK: (465 ppm N, 200 ppm P ,380 ppm K)

soil moisture content, contributes to these results. These findings were agreed with the results obtained by Agbodjalo *et al*. (2016).

Results of table 3 show that the interaction between type and level of added fertilizer significantly affects the potassium content of corn. The NPK fertilizer treatment at level of 0 kg ha^{-1} yielded the lowest rate, reaching 12.23 gm km^{-1}. In comparison, the NPK fertilizer coated with chitosan at a ratio of 1:3 at the 2 kg ha^{-1} level produced the highest yield, reaching 44.15 gm kg^{-1}. These differences were statistically significant compared to the other treatments, with a percentage increase of 72.29% compared to the NPK fertilizer treatment at 0 kg ha^{-1} level. These results agreed with the findings of Abdel Rahman *et al*. (2020) regarding the effect of chitosan and chemical DAP fertilizer on barley productivity in northern Jordan. The study showed a 10% increase in crop productivity when using a mixture of chitosan and chemical fertilizer compared to the control treatment.

The results of table 3 indicated a significant interaction effect between the level of organic matter and the level of added fertilizer on the potassium content of corn. The control treatment yielded the lowest potassium content, reaching 11.65gm km^{-1}, while the fertilized treatment at the level of 2.5 tons ha^{-1} of organic matter and 2 kg ha^{-1} of fertilizer, produced the highest potassium content, reaching 41.08 gm kg^{-1}. It represents an 71.64% increase compared to the control treatment, and the differences were statistically significant compared to the other treatments.

Results of table 3 showed a significant effect between the type of fertilizer, level of fertilizer, and level of organic matter on the potassium content of corn plant. The NPK fertilizer coated with chitosan at a ratio of 1:3 at the level of 2 kg ha^{-1} of fertilizer and 2.5 tons ha^{-1} of organic matter yielded the highest potassium content of 47.07gm kg^{-1}. It was followed by the NPK fertilizer mixed with chitosan

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at a ratio of 1:3 at 2 kg ha^{-1} of fertilizer and 2.5 tons ha^{-1} of organic matter with a yield of 44.09 gm km^{-1}. The NPK fertilizer coated with chitosan at a ratio of 1:3 at 2 kg ha^{-1} of fertilizer and 0 tons ha-1 of organic matter yielded a potassium content of 26.36gm km^{-1}. These results indicate the role of chitosan in an increasing of total yield of grain of corn and the necessity of using it to enhance the availability of essential nutrients for plant growth, reflecting an increase in growth parameters, including yield of corn plants. These findings agreed with the results obtained by Mondal *et al*. (2012).

III. Conclusions

NPK-Chitosan increased the phosphorus and potassium content corn plant and its role was increased with addition of organic matter. Fertilizer NPK-Chitosan can be used in calcareous soils, as slow release fertilizer when it is mixed or coated with mineral NPK fertilizer .

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