Middle East Journal of Applied Sciences
Volume: 14 | Issue: 03| July – Sept. | 2024

EISSN: 2706 -7947 ISSN: 2077- 4613
DOI: 10.36632/mejas/2024.14.3.38
Journal homepage: www.curresweb.com
Pages: 518-528

Study the Efficiency of Using Rock Phosphate with Organic and Biological Fertilization on Wheat Yield

Fatma EL-zhraa M.M. Abo El Amayem, Nashwa M. El-Sheikh and Rania A. El-bialy

[1]Soil, Water and Environment Research Institute, ARC, Giza, Egypt

Received: 11 July 2024 **Accepted:** 15 August 2024 **Published:** 30 August 2024

ABSTRACT

The main objective of the current study was to evaluate the effect of Phosphate rock (PR), application either alone or with some activators such as FYM and PSB wheat, growth characteristics, yield components, and some soil properties. Phosphorus (P) is often the limiting factor for plant growth because of its low mobility and availability in soils. Rock phosphates naturally occurring cheaper mean of phosphorus (P) availability but having drawback of poor solubility. A field experiment was conducted. At the Ismailia Research Station, an agricultural research station in the Ismailia governorate of Egypt, during the two succeeding growing seasons of 2021–2022 and 2022–2023 to evaluate the effects of tow source phosphorus (P) (20 kg super phosphate/fed, 1 ton /fed rock phosphate and 2 ton /fed rock phosphate),with natural stimulants application interaction with natural stimulants of farmyard manure (FYM) and phosphate solubilizing bacteria on Wheat growth and soil properties .The experiment design was a split-plot with three replicates. The results illustrated that rock phosphate application (2.0 tons/fed) recorded the significantly highest values of all studied parameters. Adding FYM achieved the significantly highest results, followed by Bio-fertilizer application compared to control. The interaction between rock phosphate application (2.0 ton/fed) and FYM gave the best means on all studied parameters during the two seasons. The positive effect of rock phosphate application individually or with FYM and Bio-fertilizer might be related to enhancing soil properties, reducing soil pH, and producing organic and growth hormones, causing an increase in nutrient uptake by plants and improving Wheat plants' growth and development.

Keywords: rock phosphate, farmyard manure, phosphate solubilizing bacteria and wheat yield

1. Introduction

Egypt has adopted a three-pronged strategy to close the production and consumption gap: developing newly reclaimed land to increase the area of wheat cultivation; increasing grain productivity (vertical expansion); and minimizing wheat losses throughout the wheat value chain from field to fork. Additionally, Egypt made good strides in creating new wheat cultivars with high productivity and practices good agricultural practices to maximize grain productivity per unit of cultivated area. Still, the expansion of wheat areas is constrained due to a lack of water resources (Yigezu *et al.,* 2021). Phosphorus is one of the major nutrients after nitrogen required for plant growth and is one of the essential nutrients to sustain all forms of life, but it is an insufficient nutrient, this is due to its complex chemical reactions in soil, and the speed of its transformation to insoluble form, makes it highly deficient nutrient in most soils (Hellal *et al*., 2019). Availability of P is compromised in those soils having high pH and high calcium content. As at higher pH, conversion of P to plant unavailable forms take place. The P fertilizer price has increased, reflecting its declining application to Wheat crops by farmers and resulting in a Wheat yield reduction. To address this issue, environmentally friendly, cost-effective, and productive farming technologies should be improved. Essentiality of P for plant growth is well known and well documented. For getting sustainable yield, exogenous application of P sources is compulsory. There are several functions of P in plants including involvement in cell metabolism, part of adenosine tri-phosphate (ATP), phospholipids, nucleic acid, DNA, RNA, role in synthesis of protein

Corresponding Author: Fatma EL-zhraa M.M., Soil, Water and Environment Research Institute, ARC, Giza, Egypt. E-mail: E-mail:batot1919@yahoo.com

etc. Overall crop growth and yield particularly, root growth and development, formation of seeds and quality of crops is seriously affected due to deficiencies of P (Ezawa *etal*., 2002; Achal *et al*., 2007; Yadav and Pandey, 2018; Calle-Castañeda *et al*., 2018). Some research has been conducted on how to raise soil phosphorus levels using mineral fertilizer, Rock Phosphate, and organic or bio-fertilization to enhance significant agronomic yield responses (Mesic *et al.,* 2016; El-Ghamry *et al.,* 2017; Hasana *et al.,* 2022; Jamal *et al.,* 2023). Phosphate rock (PR), also known as fluorapatite, mainly contains calcium phosphate minerals and is extracted from geologic and marine deposits. The PR dissolves slowly when added to soil, which allows nutrients in the soil solution to be uptaken by plants. P fertilizers are made from PR, such as mono-amonium phosphate (MAP), di-amonium phosphate (DAP), single super phosphate (SSP), and triple super phosphate (TSP). The application of PR has become as effective as superphosphate, yet PR reduces the cost of chemical fertilizer and environmental pollution (Nayak *et al.,* 2013; El-Ghamry *et al.,* 2017; Hellal *et al.,* 2019)

Organic manures, known as farmyard manure (FYM), that may be partially or totally replace chemical P fertilizers for reducing the dependency on including P-ones. (Khan *et al.,* 2022; Jamal *et al.,* 2023). FYM increases soil organic carbon and lower concentrations of P, which is bound with different molecules that should be decomposed to modify it to inorganic phosphates and allow plant absorption from the soil (Hopkins and Hansen, 2019). Also, FYM contains all valuable nutrient source for plant such as nutrients (N, P and S), micro-nutrient and organic acids that could enhance P motion and bio-availability through the soil. Organic manures improved soil physical, chemical and biological properties by increasing soil organic matter (SOM), soil aggregation, bulk density, penetration resistance and water hold capacity. That caused to enhance soil nutrient cycling and offers a good environment for plants growth and development (Singh *et al.,* 2022). Bio-fertilizers are considered an alternative to chemical fertilizers with more advantages, they play a vital role in enhancing the growth as well as the yield of plant crops, increasing the soil fertility, where they contain microscopic microorganisms that are used as fertilizers for plant growth such as Azospirillum sp. and Azotobacter sp (Itelima *et al*., 2018). Therefore, it has many advantages in organic agriculture, controlling environmental pollution and in the improvement of soil health as well as in reducing input use (Gutiérrez-Rojas *et al*., 2011; Jalilian *et al*., 2012). According to Cercioglu *et al.* (2014) and Kumar & Urmila (2018). Wheat (*Triticum aestivum* L.) is considered the world's major cereal crop regarding cultivated area and total production. It provides almost 20% of food energy for people in Egypt. Increasing wheat production is the ultimate goal to reduce the wide gap between production and consumption which amounts to 40% of production.

2. Materials and Methods

To attain the aim of the study, an experiment was carried out in two seasons, 2021/2022 and 2022/2023 at the experimental farm of at Ismailia Research Station, Agricultural Research Center in Ismailia governorate Egypt. This experiment followed a split plot design with three replications in which the main plots were randomly assigned to tow source phosphorus applications including 20 kg superphosphate/fed., 1.0 ton Rock Phosphate/fed., and 2.0 ton Rock Phosphate/fed. The sub-plots were randomly assigned for three treatments as follows: control, bio-fertilizer and organic manures (FYM) to evaluate the effect of Rock Phosphate application with some activators such as FYM and Bio-fertilizer on Wheat constituents, yield components, and soil properties. Seeds of (Sakha 98) (*Triticum aestivum* L.) in sandy soil conditions under the spray irrigation system. Plants varieties where the winter crop was sown on the 3rd week of November 2021/2022 and 2022/2023. At the end experiment (180 days), wheat plants were harvested. Their treatments were as follows:

- Control
- Phosphorus application (20 kg/fed superphosphate, 1 ton /fed Rock Phosphate and 2 ton /fed Rock Phosphate
- Stimulants (Bio-fertilizer and Farmyard manure)

Soil analysis

- Following harvest, surface soil samples (0.0–30 cm) were collected to measure soil properties, such as pH was determined in a soil: water suspension (1:2.5) using a pH meter.

- EC Total salinity and soluble ions in the saturated paste extract, were determined according to Richards (1954).
- Organic matter (O.M) % was determined according to the modified method of Walkley and Black (Jackson 1973). Available P, K were determined by extracting the soil with Ammonium-Bicarbonate- DTPA, (AB+DTPA according to Soltanpour (1985).
- Phosphorus was measured colormetrically; K was measured by Flam Photometer. Total nitrogen was determined by micerokjeldahl method as described by Chapman and Pratt (1961).
- Heavy metals content was determined according Tessier *et al*. (1979).

Plant analysis

One cut was taken from each plot after 150 days of sowing. Samples of plants were oven dried at 70º and were subjected to wet digestion using concentrated Sulfuric/Perchloric acids mixture (H_2SO_4+ $HCLO_4$). Digests were diluted with water to 50 ml and phosphours determined colorimetrically. A sample of 0.5 g of the dried plant material was digested using a 20:5 mixture of sulfuric acid to hydrogen peroxide (Agiza *et al.,* 1985 and Lowther, 1980) and then potassium, phosphorus and nitrogen were determined in digests using the methods as described for the soil analysis. Total NPK uptake by plant was calculated according to Dobermann (2005) as follow:

N, P or K Uptake (mg pot-1) = N, P or K concentration (mg kg-1) in plant part (dry matter) × dry biomass (g pot-1) /1000

Statistical analysis

The variables analyzed by ANOVA using M Stat-C statistical package (Freed, 1991). Mean comparisons were done using method of least significant differences (L.S.D) at 5% level ($P \leq 0.05$) of probability for comparing differences between the means (Snedecor and Cochran, 1988).

Table 1: Physical and chemical properties of the investigated soil

Property	Value	Property	Value
Sand %	94	Moisture%(w/w)	
Silt %	2	Field capacity	18.64
Clay %	4	Wilting point	3.61
Texture class	Sand	Available water	14.83
OM %	0.11	Bulk density(g cm^{-3})	1.64
$CaCO_3$ %	0.21	Total porosity%	37.36
pH	8.0	Hydraulic Conductivity (cm hr^{-1})	18.64
Sp	30	**Available macronutrients (mg kg^{-1})**	
EC dSm^{-1}	2.25	N	22.90
Soluble ions* $mmol_cL^{-1}$		P	2.97
Ca^{2+}	5.9	K	109.33
Mg^{2+}	4.0		
Na^{+}	12.3		
K^{+}	0.3		
HCO_3^{-}	1.2		
Cl^{-}	17.2		
SO_4^{2-}	4.1		

Notes: no CO_3^{2-} Was detected; pH (1:25 w:v soil water susp.); EC (saturation extract.) OM (organic matter) *Critical levels of the available nutrient (mgkg^{-1}) N=<40.0 “Low”; 40.0-80.0 “Medium”; >80.0 “High” P=<5.0 “Low”; 5.0-10.0 “Medium”; >10.0 “High”; and K= <85” Low”; 85-170 “Medium”; >170 “High” according to Soltanpour &Schwab (1977).

Table 2: The chemical composition analysis of Rock Phosphate**.**

P_2O_5	SiO_2	MgO	AL_2O_3	Fe_2So_3	Na_2O	K_2O	EC dS m	pH	$CaCo_3$
30%	9.1 %	0.6%	0.8%	1.2%	0.4%	0.05%	3.55	8.66	8.82%

Table 3: The chemical composition analysis of Compost properties.

EC (dSm^{-1})	pH (1:2.5)	Total Macronutrient (%)			Total Micronutrient (mg kg^{-1})			C/N ratio	OM %	Bulk density (gcm^{-3})	Moisture %	Ash	WHC %
		N	P	K	Fe	Mn	Zn						
3.50	7.44	1.10	**0.82**	**2.2**	320	**65**	**50**	17.8	37.7	0.35	11.8	42	160

Notes: WHC %= water holding capacity; BD gcm^{-3}=bulk density

3. Results and Discussion

3.1. Effect of superphosphate and rock phosphate and natural stimulants application (FYM and Bio-fertilizer) on the growth of the wheat plant

Data provided in Table (4) demonstrated that the effect of phosphorus application (20 kg superphosphate/fed, 1 ton /fed rock phosphate and 2 ton /fed rock phosphate) with natural stimulants application (FYM and Bio-fertilizer) and their interaction on Wheat growth characteristics as Plant height, Weight1000, dry matter, HI%, Protein%, Biology and root length. The data in the Table (4) indicated that, most investigated treatments with applying rock phosphate significantly increased the height of wheat plant and root length compared to the treatments with applying superphosphate. The highest plants height were for applying rock phosphate under level 2 ton fed which recorded 55 in S2 , 45, 42 and 40 cm respectively compared to the superphosphate treatment (29 cm). The best results recorded the application of rock phosphate (2.0 ton/fed) with FYM treatment, followed by applying rock phosphate (2.0 ton/fed) with Bio-fertilizer treatment compared to other treatments. Compost is described as biooxidation and stabilization of organic material involving the joint action of earthworms and mesoplilic microorganisms (Patil, 2010). Weight1000(g) was give the highest 31.1 (g) with applying rock phosphate 2 ton fed with FYM treatment. Data presented in Table (4) show that, most investigated treatments with applying rock phosphate with natural stimulants application (FYM and Bio-fertilizer) significantly increased the dry matter compared to the treatments with applying superphosphate (15.5% P_2O_5). under level 2 ton fed of rock phosphate which recorded 30.1 g in S2 compared to the superphosphate treatment (22.4 g). While HI% recorded 86’ 70’69’68and 58. And percentage of Protein statistically was 14.7 % with 1ton fed of Rock Phosphate with natural stimulants application (Bio-fertilizer). Biology mathematically was 5.7 with 2ton fed of Rock Phosphate with natural stimulants application (FYM) same data with1ton fed of rock phosphate single. In addition, the same treatments give the highest plants root length, which was recorded at 11.9 with 2ton fed of rock phosphate compared to the superphosphate treatment (7 cm). Moreover, the data presented in Table (4) show that, most investigated treatments with applying rock phosphate with FYM treatment significantly increased the dry matter compared to the treatments with applying superphosphate. This may be due to, some microbial strains such as acid-producing bacteria and fungi, they directly enhance plant growth through produce substances that stimulate plant development and enhance the mobilizing of nutrients, also help to solubilize insoluble unavailable forms of nutrients compounds resulting in increased nutrients availability in the soil. They also improve the chemical and biological characteristics of soil by dissolving the calcium carbonate, reduction of soil pH and help accelerate leaching the soluble salts with irrigation water. This helps increase plant growth and reflected in the plant growth characteristics studied. Similar results found by (Abo-baker 2017; Farrag and Bakr 2021).Also from the data in Table (4) we found that, increased the plant height, root length and dry matter yield of wheat plants in most treatments when applying rock phosphate with natural stimulants application (FYM and Bio-fertilizer) Our results agree with the results of Fiorentino *et al.,* (2018) who have significantly the growth parameters of plants such as the plant height, biological yield, biomass yield and root length, over control. The positive effect of rock phosphate on the improvement of plant growth has been linked to several direct and indirect effects on plants, including the release of substances such as volatile organic

Table 4: Effect of superphosphate and rocks phosphate and natural stimulants application (FYM and Bio-fertilizer) on the growth of the wheat plant

Treatments		Plant height (cm)		Weight 1000(g)		Dry matter		HI %		Protein %		Biology		Root length (cm)	
Phosphorus application (A)	**Stimulants (B)**	**S1**	**S2**	**S2**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
20kg/fed Superphosphate	**Control**	20	21	27.1	28.2	22.1	22.4	65	66	10.7	13.3	4.3	5.1	7.1	7.0
	Bio-fertilizer	19	20	26.2	24.1	24.1	23.9	59	61	10.8	11.4	4.5	3.9	8.2	8.8
	Farmyard manure	27	29	30.1	29.1	28.1	27.2	58	60	11.3	12.2	3.6	3.1	8.1	9.2
Mean		**22**	**23.3**	**27.8**	**24.7**	**24.7**	**24.5**	**60.6**	**62.3**	**10.9**	**12.3**	**4.4**	**4.0**	**7.8**	**8.3**
1 ton /fed Rock phosphate	**Control**	33	38	22.1	22.3	27.9	25.7	66	70	12.5	13.5	5.7	5.6	8.2	9.2
	Bio-fertilizer	30	31	24.1	28.2	22.2	27.3	63	86	17.3	18.8	5.2	4.7	8.3	9.0
	Farmyard manure	38	33	28.1	29.1	25.3	29.1	66	65	16.1	17.9	4.6	5.7	10.8	10.5
Mean		**33.6**	**34**	**24.7**	**26.5**	**25.1**	**27.3**	**65**	**73.6**	**15.3**	**16.7**	**5.1**	**5.3**	**9.1**	**9.5**
2 ton /fed Rock phosphate	**Control**	40	42	27.9	23.1	28.2	27.1	68	69	13.9	13.9	5.2	5.7	10.3	11.9
	Bio-fertilizer	40	45	22.2	25.1	24.1	26.2	66	67	14.3	15.7	5.1	4.7	9.7	11.1
	Farmyard manure	44	55	25.3	31.1	29.1	30.1	69	70	13.2	14.7	4.6	4.9	11.4	11.7
Mean		**41.3**	**47.3**	**25.1**	**26.4**	**27.1**	**27.8**	**67.6**	**68.6**	**13.8**	**44.3**	**4.9**	**5.1**	**10.4**	**11.5**
LSD at 0.05	**A**	1.15	1.19	n.s	n.s	0.03	0.04	1.02	1.1	0.55	0.45	1.73	1.95	0.50	0.72
	B	1.33	1.55	1.50	1.60	n.s	n.s	1.08	1.09	n.s	n.s	ns	ns	ns	ns
	AB	2.01	1.90	n.s	n.s	0.01	0.05	2.0	1.89	n.s	n.s	ns	ns	ns	ns

compounds as well as small peptides, which enhance root system architecture (root length,) with auxin activity.

3.2. Effect of superphosphate and rocks phosphate with natural stimulants application (FYM and Bio-fertilizer) on the on-plant nutrients uptake.

N, P and K concentration in wheat plant. Data presented in Table (5) indicated that, N, P and K percent in wheat plants showed response to inoculation with the selected microorganisms under the different doses of rock phosphate application. Significant increase in the amounts of N, P and K -percent in wheat plant in as a result of applying rock phosphate at the level of 2 ton compared to the superphosphate treatment and rock phosphate without inoculated, also in most treatments, significant increase in the amounts of N, P and K -percent in wheat plant in as a result of applying rock phosphate with natural stimulants application (FYM). The highest values of N, P and K in wheat plants were recorded for rock phosphate at the level of 2 tons.

3.3. N, P and K uptake of wheat plants

Uptakes of N, P and K by wheat plants cultivated in the soil amended with the different treatments under study during growth season is considered an indication of the treatment effects on the ability of the plant to take advantage of the available amount of nutrients in the soil. The data in Table (5) demonstrated that, the highest uptake values of N, P and K by wheat plants were recorded for treatments when applied 2 ton /fed rock phosphate with natural stimulants application (FYM), which displayed 150, 9.4 and 127 N, P and K respectively. Application of rock phosphate combined with natural stimulants application and phosphate dissolving bacteria such as Bacillus (Bio) led to an increase in the uptake of N and K by plants, which may be due to some strains of phosphate dissolving bacteria such as *Bacillus* can produce some organic acids as well as CO2 these substances convert the insoluble forms of some nutrients like P into soluble forms, this led to increases of concentration-nutrients in the vicinity of plant roots .and its availability in the soil solution as well as reduces. Its fixation by soil factors. Also, these strains have the ability to produce some substances and enzymes that can promote growth and extension of the plant roots, this helps to increase the ability of the roots to absorb nutrients from the soil. These results are in agreement with those of (Abo-baker, 2017; Farrag and Bakr, 2021). In addition, from the data in a Table (5) we found that, increase in the amounts of uptakes of N, P and K by wheat plants in most treatments whine applying rock phosphate. Growth was supported; However, due to the involvement of several mechanisms involved in natural stimulants application -plant interactions, it was not possible to conclude that the mineral solubilization. by natural stimulants application was primarily responsible for promoting plant growth, in addition, the improvements on the root system under natural stimulants application affected which includes increases in lengths and volumes of root and the numbers of root tips, may have enabled the roots to maintain better contact with the minerals examined in this study these findings are of great significance for nutrient uptake when nutrients are scarce.it is one of the processes through which natural stimulants application affects plant growth. Several studies found that, the addition of organic amendments such as compost led to increase of the available phosphorus in soil (Scherer & Sharma, 2002; Qian & Schoenau, 2000). There are a direct and indirect positive effect for the addition of compost the direct positive effect could be ascribed to the phosphorus released from compost. The indirect effect could be returned to the production and release of organic acids and stimulation of microbial activity that can decrease the soil ph. This effect could be led to increasing the release and mobilization of phosphorus in soil (Ayaga *et al*., 2006; Fuentes *et al*., 2006; and Khan and Joergensen, 2009).

We found that, increase in the amounts of uptakes of N, P and K by wheat plants in most treatments whine applying rock phosphate biocombined with bacteria (*Bacillus megathirum or Bacillus polymyxa*). Li *et al.* (2015) found that the use of *Bacillus* increased plant growth and enhanced nutrient uptake by plants and thus. promoted plant. growth was supported; However, due to the involvement of several mechanisms involved in Trichoderma-plant interactions, it was not possible to conclude that the mineral solubilization. by *Bacillus megathirum* was primarily responsible for promoting plant growth, in addition, the improvements on the root system under *Bacillus megathirum* affected which includes increases in lengths and volumes of root and the numbers of root tips, may have enabled the roots to maintain better contact with the minerals examined in this study these findings are of great significance

Table 5: Effect of superphosphate and rocks phosphate with natural stimulants application (FYM and Bio-fertilizer) on the on-plant nutrients uptake

Treatments		Plant nutrient uptake (kg /fed-1)											
Phosphorus application (A)	stimulants (B)	Plant nutrient concentration (%)						Plant nutrient uptake					
		N		P		K		N		P		K	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
20kg/fed Superphosphate	Control	1.7	2.0	5.9	7.2	1.1	1.3	81	82.3	5.6	6.9	80.7	81.2
	Bio-fertilizer	2.7	3.7	6.3	7.4	1.3	1.6	105	111	6.4	7.1	102	101
	Farmyad manure	3.8	4.1	5.7	6.4	1.8	2.1	143	144	8.7	8.9	117.8	118
Mean		**2.7**	**3.2**	**5.7**	**7.0**	**1.4**	**1.6**	**109.6**	**112.4**	**6.9**	**7.6**	**99.9**	**100**
1 ton /fed Rock phosphate	Control	3.1	3.2	6.6	9.5	2.0	2.1	52.3	55	5.3	6.1	77.5	77.8
	Bio-fertilizer	4.6	3.4	8.0	9.0	2.1	2.0	89	88	6.8	7.2	84.3	88.3
	Farmyad manure	4.7	4.3	9.1	8.2	2.1	1.9	148	117	8.3	8.9	105.2	1114
Mean		**4.1**	**3.6**	**7.9**	**8.9**	**2.0**	**2.0**	**96.3**	**97.6**	**6.8**	**7.4**	**95.9**	**97.7**
2 ton /fed Rock phosphate	Control	2.7	3.0	7.2	6.4	2.1	1.4	62	66	4.2	5.6	70.1	74.4
	Bio-fertilizer	2.9	3.1	7.1	8.8	1.7	1.9	111	112	7.2	8.3	75.9	109.4
	Farmyad manure	3.1	3.5	8.2	9.6	2.2	1.9	114	150	8.3	9.4	126	127
Mean		**2.9**	**3.2**	**7.5**	**8.2**	**2.0**	**1.7**	**95.6**	**98.3**	**6.5**	**7.7**	**83.7**	**99.2**
LSD at 0.05	A	0.8	0.5	0.54	0.37	n.s	n.s	0.90	0.51	0.63	0.57	n.s	n.s
	B	0.91	0.7	0.6	0.4	n.s	n.s	0.97	0.76	0.72	0.61	n.s	n.s
	AB	0.41	0.22	0.23	0.3	n.s	n.s	0.55	0.47	0.32	0.33	n.s	n.s

for nutrient uptake when nutrients are scarce.it is one of the processes through which *Bacillus megathirum* affects plant growth

3.4. Effect of demonstrated the effect of phosphorus application with natural stimulant application on Some Soil Chemical Properties after harvesting in two seasons.

The information in Table (6) demonstrated the effect of phosphorus application (20 kg/fed superphosphate, 1 ton /fed rock phosphate, and 2 ton /fed rock phosphate) with natural stimulant application (Farmyard manure and Bio-fertilizer), and their interaction on the changes in the soil pH, Ec (electronic conductivity), soil organic matter, and soil available N, P, and K following wheat harvesting during the season 1 and season 2. Also, from the data in Table (6) we found that, the available soil phosphorus significantly increased with applying rock Phosphate and superphosphate with natural stimulant application (Farmyard manure and Bio-fertilizer) compared to control. at the level 2 ton /fed Rock Phosphate with natural stimulant application (Farmyard manure and Bio-fertilizer) increased of available soil phosphorus compared to superphosphate with natural stimulant application (Farmyard manure and Bio-fertilizer).

The best results were achieved by the application of 2 ton /fed Rock Phosphate with Farmyard manure and Bio-fertilizer, followed by 1 ton /fed Rock Phosphate with Bio-fertilizer compared to superphosphate application with Farmyard manure and Bio-fertilizer. 2 ton /fed rock Phosphate with Farmyard manure recorded the highest amount of available P in the soil after harvesting by 19.4 % in season one and 19.9 % in season two, respectively, compared with 20 kg/fed superphosphate super phosphate application with Farmyard manure.

The finding in Table (6) demonstrated that natural stimulant applications (Farmyard manure and Bio-fertilizer) significantly affected all soil properties after wheat harvesting during the two seasons compared to control. The application of Farmyard manure achieved the highest means, followed by the Bio-fertilizer application compared to control. As for the interaction between Rock Phosphate application and stimulant application, results showed that this combination significantly affected all studied soil properties in both seasons. The interaction between 2 ton /fed Rock Phosphate with natural stimulant application (Farmyard manure and Bio-fertilizer) recorded the highest available N, K, EC, and organic matter values in both seasons. On the other hand, the application of 20 kg/fed superphosphate with natural stimulant application (Farmyard manure and Bio-fertilizer) gave the showed that this combination significantly affected all studied soil properties of soil N, P, K, and organic matter values in both seasons. organic acids and CO2 produced resulting from the activity of the microbial strains used and decomposition of organic matter additive before planting, this plays a role to lower the soil pH and these products help to convert the insoluble forms of P into soluble ones. All of these have significant effects on increasing the phosphorus availability in the soil. Similar results were obtained by Farrag and Bakr (2021); Habib (2021). Adnan *et al.* (2017) found that, that acid-generating bacteria like Bacillus can modify the nutrition of P and increase its solubility in soil by a variety of processes for example, they can lower the pH of the soil by producing organic acid and mineral acids, which encourage P solubility in soil.

4. Conclusion

The application of rock phosphorus treated with natural stimulants application (FYM and Bio-fertilizer) improve P release from rock phosphate and available of soil phosphorus. In addition, plant height, root lengths, dry matter content and N, P and K uptake of wheat plants compared to the other treatments.

Table 6: The study investigates the impact of the application rate of rock phosphate and superphosphate, in combination with stimulant applications (Farmyard manure and Bio-fertilizer) on soil pH, EC and available macro-micronutrients content (N, P, K) after harvest (in values of the two seasons).

Treatments		pH		EC (dSm^{-1})		O.M (%)		Available (mg/kg)					
Phosphorus application (A)	Stimulants (B)	S1	S2	S1	S2	S1	S2	N		P		K	
								S1	S2	S1	S2	S1	S2
20kg/fed Super phosphate	Control	8.01	7.88	1.61	2.30	0.29	0.31	30.11	30.11	4.11	4.29	180.00	182.12
	Bio-fertilizer	8.10	8.01	1.88	1.67	0.30	0.32	31.20	31.20	4.88	4.98	190.65	193.30
	Farmyard manure	8.02	8.00	1.64	2.07	0.47	0.46	34.88	34.88	4.90	5.00	194.70	196.47
Mean		**8.04**	**7.96**	**1.71**	**2.01**	**0.35**	**0.36**	**32.06**	**32.06**	**4.63**	**4.76**	**188.45**	**190.63**
1 ton /fed Rock phosphate	Control	8.11	7.99	1.99	2.04	0.33	0.35	32.80	33.80	4.77	5.05	190.90	198.36
	Bio-fertilizer	8.07	8.12	1.90	2.11	0.34	0.36	33.71	34.11	4.90	5.30	196.80	200.00
	Farmyard manure	8.04	7.96	1.51	2.04	0.44	0.46	35.11	37.88	5.01	5.88	198.90	202.30
Mean		**8.07**	**8.02**	**1.8**	**2.06**	**0.37**	**0.39**	**33.87**	**35.26**	**4.89**	**5.41**	**195.53**	**200.22**
2 ton /fed Rock phosphate	Control	7.91	8.07	2.11	1.40	0.35	0.37	34.17	36.08	4.90	5.59	200.80	208.12
	Bio-fertilizer	8.02	8.11	2.55	1.70	0.40	0.42	36.11	39.81	5.00	5.91	203.60	210.80
	Farmyard manure	7.99	8.06	2.50	2.08	0.48	0.50	40.11	41.50	6.08	.621	207.80	214.56
Mean		**7.97**	**8.08**	**2.39**	**1.73**	**0.41**	**0.43**	**36.80**	**39.13**	**5.33**	**5.8**	**204.0**	**211.1**
LSD at 0.05	A	n.s	n.s	n.s	n.s	0.0010	0.0011	1.79	1.80	0.12	0.14	1.52	11.55
	B	n.s	n.s	n.s	n.s	0.0013	0.0014	2.51	1.53	0.17	0.19	1.24	16.27
	AB	n.s	n.s	n.s	n.s	0.0062	0.0063	1.12	1.15	0.07	0.09	1.25	7.29

References

Abo-baker, A.A., 2017. Successive Application Impact of Some Organic Amendments Combined with Acid Producing Bacteria on Soil Properties, NPK Availability and Uptake by Some Plants. International J. of Current Microbiology and Applied Sciences. 6(3): 2394-2413.

Achal, V., V.V. Savant and R.M. Sudhakara. 2007.Phosphate solubilization by wide type strain and UV-induced mutants of Aspergillus tubingensis. Soil Biol.Biochem., 39: 695-699.

Adnan, M., Z. Shah, S. Fahad, M. Arif, M. Alam, I.A. Khan, I.A. Mian, A., Basir, H. Ullah, M. Arshad, I. Rahman, S. Saud, M.Z. Ihsan, Y. Jamal, H.M. Amanullah, Hammad, and W. Nasim, 2017. Phosphate-Solubilizing Bacteria Nullify the Antagonistic Effect of Soil Calcification on Bioavailability of Phosphorus in Alkaline soils. scientific reports, 7: 16131. |https://www.nature.com/articles/s41598-017-16537-5.

Agiza, A.H., M.I. Hineidy, and M.E. Ibrahim, 1985. Determination of different fraction of phosphorus in plant and soil. Bull FAO. Agric. Cairo, Univ. 121.

Ayaga, G., A. Todd and P.C. Brookes, 2006. Enhanced biological cycling of phosphorus increases its availability to crops in low-input sub-Saharan farming systems. Soil Biology and Biochemistry, 38(1): 81–90.

Calle-Castañeda, S.M., M.A. Márquez-Godoy and J.P. Hernández-Ortiz, 2018. Phosphorus recovery from high concentrations of lowgrade phosphate rocks using the biogenic acid produced by the acidophilic bacteria Acidithiobacillus thiooxidans. Minerals Eng.,115:97-105. https://doi.org/10.1016/j.mineng.2017.10.014

Cercioglu, M., B. Okur, S. Deli, and A.R. Ongun, 2014. Changes in physical conditions of a course textured soil by addition of organic wastes. Eurasian Journal of Soil Science, 3: 7-12.

Chapman, H.D. and Pratt, P.F. (1961) Methods of analysis for soils, plants and waters. University of California, Los Angeles, 60-61, 150-179.

Dobermann A.R., 2005. "Nitrogen Use Efficiency State of the Art Agronomy and Horticulture -- Faculty Publications, University of Nebraska, Lincoln.

El-Ghamry, A., E. El-Naggar, and H. Hassan, 2017. The Role of Organic and Bio-Fertilizers in the Validity of Phosphate Fertilizers and their Effect on the Faba Bean Grown in Clay Soil. Journal of Soil Sciences and Agricultural Engineering, 8(10): 531-538.

Ezawa, T., S.E. Smith and F.A. Smith, 2002. P metabolism and transport in AM fungi. Plant Soil, 244: 221-230. https://doi.org/10.1007/978-94-

Fuentes, B., N. Bolan, R. Naidu and M.D.L.L. Mora, 2006. Phosphorus in Organic Waste-Soil Systems. Revista de La Ciencia Del Suelo y Nutrición Vegetal, 6(2): 64–83.

Gutiérrez -Rojas, I., A.B. Torres-Geraldo, and N. Moreno-Sarmiento, 2011. Optimizing carbon and nitrogen sources for Azotobacter chroococcum growth. African Journal of Biotechnology. 10: 2951-2958.

Habib, A.A.M., 2021. Response of Pearl Millet to Fertilization by Mineral Phosphorus, Humic Acid and Mycorrhiza Under Calcareous Soils Conditions. Egypt. J. Soil Sci., 61(4): 399 – 411.

Hasana, H., S. Beyene, A. Kifilu, and S. Kidanu, 2022. Effect of phosphogypsum amendment on chemical properties of sodic soils at different incubation periods. Applied and Environmental Soil Science, 18(2): 253-262.

Hellal, F., S. El-Sayed, R. Zewainy, and A. Amer, 2019. Importance of phosphate pock application for sustaining agricultural production in Egypt. Bulletin of the National Research Centre, 43:1-11.

Hopkins, B.G., and N.C. Hansen, 2019. Phosphorus management in high-yield systems. Journal of Environmental Quality, 48(5): 1265-1280. https://doi.org/10.4067/S0718-27912006000200006

Itelima, J., W. Bang, I. Onyimba, and E. Oj, 2018. A review: Biofertilizer; a key player in enhancing soil fertility and crop productivity. Journal of Applied Biotechnology Reports, 2: 22-28.

Jackson, M.L. (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 498.

Jalilian, J., S.A.M. Modarres- Sanavy, S.F. Saberali, and K. Sadat Asilan, 2012. Effects of the combination of beneficial microbes and nitrogen on sunflower seed 23 yields and seed quality traits under different irrigation regimes. Field Crops Research, 127: 26- 34.

Jamal, A., M.F. Saeed, A. Mihoub, B.G. Hopkins, I. Ahmad, and A. Naeem, 2023. Integrated use of phosphorus fertilizer and farmyard manure improves wheat productivity by improving soil quality and P availability in calcareous soil under sub humid conditions. Frontiers in Plant Science, 14: 1034421.

Khan, I.A., A. Jamal, A. Mihoub, O. Farooq, M. Farhan Saeed, and M. Azam, 2022. Partial substitution of chemical fertilizers with organic supplements increased wheat productivity and profitability under limited and assured irrigation regimes. Agriculture, 12(11): 1754-1762.

Khan, K.S. and R.G. Joergensen, 2009. Changes in microbial biomass and P fractions in biogenic household waste compost amended with inorganic P fertilizers. Bioresource Technology, 100(1): 303–309. https://doi.org/10.1016/j.biortech.2008.06.002

Kumar, A.U., 2018. Impact of biofertilizers in enhancing growth and productivity of wheat: A review. International Journal of Chemical Studies, 6(4): 360-362.

Li, R.X., F. Cai, G. Pang, Q.R. Shen, R. Li, and W. Chen, 2015. Solubilisation of phosphate and micronutrients by Trichoderma harzianum and its relationship with the promotion of tomato plant growth. PLoS One, 10 (6): e0130081.

Lowther, J.R., 1980. Use of a single sulphuric acid - hydrogen peroxide digest for the analysis of pinus radiata needles. Communications in Soil Science and Plant Analysis. J., 11: 175-188.

Tessier, A.P., C.G. Cambell, and M. Bisson, 1979. Sequential extraction procedure for speciation trace metals. Anal. Chem., 51: 844-851.

Mesic, M., L. Brezinscak, Z. Zgorelec, A. Perčin, I. Sestak, D. BilandZija, and H. Lisac, 2016. The application of phosphogypsum in agriculture. Agriculturae Conspectus Scientificus, 81(1): 7-13. of phosphate solubilizing bacteria from agriculture soil of Jaipur, Rajasthan. Int. J. Curr. Trends Sci. Technol., 8 (20):180-191.

Richard, L.A. (1954) Diagnosis and Improvement of Saline and Alkali Soils. US Department of Agriculture. Agricultural Handbook No. 60, Washington DC, 7-53.

Patil, N.M., 2010. Biofertilizer effect on growth protein and carbohydrate contents in stevia Rebaudiana Var. Bertoni. Recent Research in Science and Technology, 2(10).

Singh, J., R.S. Bhatt, B.S. Dhillon, A.A. Al-Huqail, and A. Alfagham, 2022. Integrated use of phosphours, farmyard manure and biofertilizer improves the yield and phosphorus uptake of black gram in silt loam soil. Plos One, 17(4): 1-10

Soltanpour, P.N. (1985). Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. Commun. Soil Sci. Plant Anal. 16: 323-318.

Soltanpour, P.N. and Schwab, A.P. (1977) A New Soil Test for Simultaneous Extraction of Macro and Micro Nutrients in Alkaline Soils. Communications in Soil Science and Plant Analysis, 8, 195-207 Snedecor, T. and F. Cochran, 1988. Statistical Methods. 7th Ed. Press, Iowa, Ames, 225 – 269.

Snedecor, T. and F. Cochran, 1988. Statistical Methods. 7th Ed. Press, Iowa, Ames, 225 – 269.

Yigezu, Y.A., M.A. Moustafa, M.M. Mohiy, S.E. Ibrahim, W.M. Ghanem, A. Niane, E. Abbas, et al., 2021. Food losses and wastage along the wheat value chain in Egypt and their implications on food and energy security, natural resources, and the environment. Sustainability, 13: 10011