

Impact of Phosphate Fertilization and Calcium Carbonate Content of Soil on Available Phosphorus in soils of different textures

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Abstract. A laboratory incubation experiment was carried out at northern technical university / technical institute hawija – plant production department laboratory to study effect the effect of phosphorude levels were added to each soil (0 , 40 ,80 , 120 ,160) mg P Kg⁻¹ soil as mono potassium phosphate,soil calcium carbonate content of soil (10,15,20) % on available phosphoruse during different incubation periods (10 , 20 , 40 , 60) day . These experience designed according complete randomized design (CRD) and 3 replications. These results showed that the available phosphoruse increased with increasing fertilizer of level added in all soils , the highest values were at the (160) mg P Kg⁻¹ reached (43.71, 38.30 , 36.70) mg P Kg⁻¹ for the soils (10 , 15 ,20) % respectively at 10 , day nursery , while for 40 , day nursery was (38.02 , 33.34 , 30.39) mg P Kg⁻¹ respectively, The calcium carbonate had an negative effect on the availability whereas as the soil content high levels of lime led to reduce of phosphorus rate was (25.78 , 22.24, 19.90) mg P Kg⁻¹ for the soils (10 , 15 ,20) % respectively at 10 days of incubation period and at 40 days of incubation period was (22.26 , 18.22 , 16.14) respectively .Also with increasing the incubation periods reduce available phosphoruse and fixed phosphorus , Percentage of fixed phosphoruse increased.

1. Introduction

Phosphate is one more useful and necessary nutrient for normal diverse enviroments around the world [1]. It is also considered this feeder for the mature and improve to plants. Due the importance of this element to the plant and the decrease in the amount dissolved in the soil solution due to its reactions with mineral and organic soil compounds and its transformation over time into formulas and forms that are unavailable for the plant, the problem of the available of this nutrient for the plant has become one of the most unique problems that calcareous soils suffer from nutrients [2]. The phosphorus status in soils containing carbonate minerals usually in general it classified is reactions often slightly soluble calcium phosphate compound [3]. Phosphorus occurs mainly in hydroxy-apatite {Ca₅(PO₄)₃(OH)} and fluoro-apatite {Ca₁₀(PO₄)₆F₂}, as orthophosphate. Soil power Hydrogen considered of the distinctive feature influential Phosphate reservation about the rhizosphere zone, Phosphate ion adsorption interactions with iron and Aluminum it consists of power hydrogen < 7, timely when pH >7.0 Calcium , magnesium cations intra the existing of minerals get ready deposition additive Phosphate [4]. despite soils containing calcite afaithful quantities of phosphate, it is in the formulas of few solublility materials because to phosphate stabilizing processes [5]. Study showed [6] that in the meantime of nursery period dropped off

readiness nutrient due it is to precipitation and adsorption processes and thus transformed into less soluble complex compounds . the rise average of added phosphate rock (PR) caused a low the phosphorus fractionation (NaHCO₃) and give the lowest value in addition it decreases with increasing incubation periods [7]. The soil of arid and semi-arid regions are characterized by their high calcium carbonate content. When the soil content exceeds 10% called calcareouse soil, carbonates are found in the form of micro particles spread throughout the soil horizones or form of visible salt aggregates [8]. It is usually well structure [9]. High of calcium carbonate content has a negative effect on plant nutrition and causes symptoms of nutrient deficiency due to organic matter and clay deficiency [10]. The aim from this is to current research to know the influence of phosphate fertilizer levels addition and calcium carbonate in available phosphorus, in addition Comparison of study the ability soils in phosphorus fixation under different incubation periods.

2. Methods and Materials

2.1. Sampling, analyses

The samples taken to the test was obtained surface layer (0–30 cm) in the Kirkuk governorate. After collection of the soil sample, unwanted roots and debris were removed and the soil samples was dried by exposure air and sifted with a sieve it's a

hole diameter is 2 mm . Soil pH (1:1), electric conductivity (EC) (1:1), organic matter was determined by wet oxidation [11], CaCO₃ (back titration method) according to [12], and mechanical analysis of soil was estimated as away [11]. Available nitrogen estimated by 2N of

potassium chloride [13], available Phosphorus was determined by the colorimetric method [3] with device light spectrum 882 nm , available potassium using NH₃CH₃COOH [14]. The results of soil analyzes are presented table (1) below.

Table 1. some chemical and physical parameters for soils before incubation

Unit	Value			Parameters
	S3	S2	S1	
—	7.6	7.6	7.5	pH
dS m ⁻¹	2.78	2.63	2.04	EC
%	0.87	0.95	1.42	Organic matter
%	20	15	10	Calcium Carbonate
Mg Kg ⁻¹	10.30	12	14	Available Nitrogen
Mg Kg ⁻¹	7.20	7.90	9.8	Available Phosphorus
Mg Kg ⁻¹	160	168	200	Available Potassium
%	46.31	37	23.6	Sand
%	20.28	48	44.2	Silt
%	33.41	15	32.2	Clay
	Sandy Clay Loam	Loam	Clay Loam	Textural Class

2.2. Incubation experiments and chemical analysis

The experiment was carried out at the northern technical university – al-hawija technical institute , plant production department laboratory. The experiment was design according to a using (CRD) with 3 duplicate duplicates and to two months of probation period, the experiment included two factors , the first is phosphate fertilizer (0 , 40 , 80 , 120 , 160) mg P Kg⁻¹ soil as KH₂PO₄ , the second is soil calcium carbonate content (10 , 15 , 20) % and it is symbol is as follows by (S1 ,S2 ,S3). the soils air-dried and sieved through a 2-mm sieve

and Plastic container were prepared and put in it 1 Kg from all soils , phosphorus was added according to the levels mentioned and 5 to 8 drops from toluene solution (C₆H₅CH₃) and added per containers to prevent the maturation microorganisms, After incorporation soil with fertilizer, the soil humidity was brought to borders field capacity and adjusted at laboratory temperature 25 °C. The stuck soil were then filtered ,through Whatman class filter paper Number.42, Olsen extracable-P was extracted with NaHCO₃ at pH 8.5 and it content was determined

by spectrophotometer. The adsorbent phosphorus, the percentage of phosphorus fixation were calculated according to the following equations :-

- Fixed phosphate = (Added phosphorus level – Available phosphorus).
- Percentage of phosphorus fixation = $\frac{\text{phosphorus fixation}}{\text{added phosphorus at different levels}} \times 100$

3. Results and Discussion

Table (2) show these results effect adding different levels of fertilizer for soils for variety of calcium carbonate content on availability that the increase the level of phosphorus from P0 to P4 at each soil led to increased available phosphorus was (8.60 to 43.71) mg P Kg⁻¹ at soil 10 % , (6.00 to 38. 30) mg P Kg⁻¹ at soil 15 % , (3.60 to 36.70) mg P Kg⁻¹

¹ at soil 20 % this consistent with the result [15], but also phosphorus decreased with increased lime was a rate (25.78 , 22.24 , 19.90) milligram P Kelogram⁻¹ , the decrease percentage in available phosphorus rate was (13.73 , 22.80) % for soil (S2 ,S3) compared soil (S1), observed the results that the calcium carbonate affected in reducing available phosphorus rate and also this is consistent with the results [16]. this decline came is due to the adsorption and precipitation reactions that element is exposed to .explain through the results that with increase phosphorus level and soil calcium carbonate content it will increased fixed phosphorus rate was (69.92 , 73.69 ,76.02) milligram P Kelogram⁻¹. those values are agree with [6]. The Percentage of fixed phosphorus rate Increased as the rates of added phosphorus and calcium carbonate content increase was (67.75 , 71.71 , 75.18) % respectively.

Table 2. Effect of phosphorus and calcium carbonate levels on Phosphorus available at 10 days of incubation period

Percentage of Fixed phosphorus %	Fixed phosphorus mg P Kg ⁻¹ soil	Available phosphorus mg P Kg ⁻¹ soil	Added phosphorus mg P Kg ⁻¹ soil	Calcium carbonate in soil %
—	—	8.60	0	
59.90	23.96	16.04	40	
66.78	53.43	26.57	80	10 %
71.66	86.00	34.00	120	
72.68	116.29	43.71	160	
67.75	69.92	25.78	Average	
—	—	6.00	0	
63.42	25.37	14.63	40	
72.85	58.28	21.72	80	15 %
74.51	89.42	30.58	120	
76.06	121.70	38.30	160	
71.71	73.69	22.24	Average	
—	—	3.60	0	
71.75	28.70	11.30	40	
75.51	60.41	19.59	80	20 %

Percentage of Fixed phosphorus %	Fixed phosphorus mg P Kg ⁻¹ soil	Available phosphorus mg P Kg ⁻¹ soil	Added phosphorus mg P Kg ⁻¹ soil	Calcium carbonate in soil %
76.40	91.68	28.32	120	
77.06	123.30	36.70	160	
75.18	76.02	19.90	Average	

table 3. show influence fertilizer , calcium carbonate content in the status phosphorus in the sample added phosphorus increased the readiness as level (160) gave the highest Compared to other levels values reached (40.59 milligram P Kelogram⁻¹ at sampling 10 % , (35) milligram P Kelogram⁻¹ at sampling 15 % and (32.56) at soil

20 % these results were consistent with [17], increasing the lime content in addition to the presence levels added reduced the availability of phosphorus at a rate of (23.83 , 19.97 ,17.51) milligram P Kelogram⁻¹ for each samples respectively, these average are compatible with results [18].

Table 3. Effect of phosphorus and calcium carbonate levels on Phosphorus available at 20 days of incubation period

Percentage of Fixed phosphorus %	Fixed phosphorus mg P Kg ⁻¹ soil	Available phosphorus mg P Kg ⁻¹ soil	Added phosphorus mg P Kg ⁻¹ soil	Calcium carbonate in soil %
—	—	7.80	0	
64.12	25.65	14.35	40	
69.48	55.59	24.41	80	10 %
73.33	88.00	32.00	120	
74.63	119.41	40.59	160	
70.39	72.16	23.83	Average	
—	—	5.82	0	
67.50	27.00	13.00	40	
76.18	60.95	19.05	80	15 %
77.48	92.98	27.02	120	
76.99	123.19	35.00	160	

74.53	76.03	19.97	Average	
—	—	2.93	0	
75.95	30.38	9.62	40	
78.55	62.84	17.16	80	20 %
78.91	94.70	25.30	120	
79.99	127.99	32.56	160	
78.35	78.97	17.51	Average	

The results of the table shows that fixed phosphorus increased with increasing levels added phosphate and increasing soil lime content at a rate of (72.16 , 76.03 . 78.97) mg P Kg⁻¹ for all soil (S1 ,S2 ,S3) in sequence and these values are consistent with the [19], while Percentage of fixed phosphoruse increased with increasing all the experiment factors and were (70.39 , 74.53 , 78.35) mg P Kg⁻¹ respectively.

Through the results of the table (4) it observed that the values available phosphorus increased with added levels the highest values were at the level (160) milligram P Kelogram⁻¹ was (38.02) milligram Kelogram⁻¹ at soil 10 % , (33.34) milligram P Kelogram⁻¹ at soil 15% , (30.39) mg P Kg⁻¹ at sample 20 % comparative control treatment for all soils in succession, these results are consistent with [7]. As for increasing the soil lime content and increasing the level of added

phosphorus cause reduced availability and rates (22.28) , (18.63) ,16.34) mg P Kg⁻¹ respectively, calcium carbonate it has a major negative role in nutrient availability as carbons increased phosphorus decreased, due to adsorption reactions phosphorus is transformed into less soluble compounds because the calcerous soils has a relatively high adsorption capacity it agree with the results [20]. Show results in table (4) that increased Fixed phosphorus and Percentage of fixed phosphoruse rates with increased experiment factors was (73.91 , 77.75 , 80.60) mg P Kg⁻¹ and (72.21 ,76.30 , 79.71) % respectively . From the results in Tables (2, 3, 4, 5) observed a decrease in phosphorus readiness as the incubation period increases and confirmed [21] explained phosphorus released was decreased with time increased, That is the longer the incubation period, the less available Phosphorus in soil.

Table 4. Effect of phosphoruse and calcium carbonate levels on Phosphoruse available at 40 days of incubation period

Percentage of Fixed phosphoruse %	Fixed phosphorus mg P Kg ⁻¹ soil	Available phosphorus mg P Kg ⁻¹ soil	Added phosphorus mg P Kg ⁻¹ soil	Calcium carbonate in soil %
—	—	7.10	0	
66.00	26.40	13.60	40	
71.61	57.29	22.71	80	10 %
75.00	90.00	30.00	120	
76.23	121.98	38.02	160	

72.21	73.91	22.28	Average	
—	—	4.20	0	
69.95	27.98	12.02	40	
77.37	61.90	18.10	80	15 %
78.74	94.49	25.51	120	
79.16	126.66	33.34	160	
76.30	77.75	18.63	Average	
—	—	2.00	0	
78.97	31.59	8.41	40	
79.12	63.30	16.70	80	20 %
79.78	95.74	24.22	120	
81.00	129.61	30.39	160	
79.71	80.06	16.34	Average	

The table [5] shows impact of fertilizer doses and calcium carbonate in phosphorus forms, the results increased phosphate fertilizer from (P0 to P4) led to an increase the available phosphorus was (6.00 -36.30) mg P Kg⁻¹ at model 10% , (4.00 – 29.66) milligram P Kelogram⁻¹ at model 15% , (1.60 – 26.00) milligram P Kelogram⁻¹ at soil 20 % , results agree within results [22], but the increase in calcium carbonate played a major role in reducing phosphorus in the soil at rates (22.28 , 18.63 , 16.34) milligram P Kelogram⁻¹ for all samples respectively, there are results agree with [18] showed There is an negative correlation to the

quantity of carbonate minerals and fertilizer, as the quantity increases CaCO₃ reduces phosphorus available to the plant and increases the amount of phosphate absorption. The amount of fixed phosphorus increased with increasing levels of phosphate and calcium carbonate , and the percentage of increase (18.35 , 31.52)% compared to the treatment (S1). The percentage of fixed phosphorus increased with increase experiment factors and was at rate of (74.86 ,77.10 , 83.05) % respectively.

Table 5. Effect of phosphorus and calcium carbonate levels on Phosphorus available at 60 days of incubation period

Percentage of Fixed phosphorus %	Fixed phosphorus mg P Kg ⁻¹ soil	Available phosphorus mg P Kg ⁻¹ soil	Added phosphorus mg P Kg ⁻¹ soil	Calcium carbonate in soil %
—	—	6.00	0	
69.78	27.91	12.09	40	
74.58	59.67	20.33	80	10 %
77.79	93.35	26.65	120	
77.31	123.70	36.30	160	
74.86	76.15	20.27	Average	
—	—	4.00	0	
72.47	28.99	11.01	40	
81.25	65.00	15.00	80	15 %
73.25	87.90	23.10	120	
81.46	130.34	29.66	160	
77.10	78.05	16.55	Average	
—	—	1.60	0	
83.75	33.50	6.50	40	
82.50	66.00	14.00	80	20 %
82.22	98.67	21.33	120	
83.75	134.00	26.00	160	
83.05	83.04	13.88	Average	

4. Conclusion

Through the above mentioned results, but it turns out that the high quantity from CaCO₃ will led to phosphorus available reduce, Increasing the level of phosphorus increased the readiness of each soil independently of the other. The longer the incubation period, the lower the readiness and the increased the fixed phosphorus and its percentage.

References

- [1] Onweremadu EU. Predicting phosphorus sorption characteristics in highly weathered soils of South-Eastern Nigeria. *Research Journal of Environmental Sciences*. 2007; 1:47-55.
- [2] Hooker ML, Paterson GA, Sander DH, Daigger LA. Phosphate fraction in

- calcareous soils as altered by time and quantity of added phosphorus. *Soil Science Society of America Journal*. 1980; **44**:369-77.
- [3] Olsen SR, Coles CV, Watanade FS, Dean LA. Determination of readily available phosphate in soil by extraction with Na_2HCO_3 . *USDA*. 1954;939.
- [4] Bubba KE, Oxtabong E, Barberies E. Phosphorus adsorption maximum of sand for use as media in material flow constructed reed beds as measured by the Langmuir isotherm. *Water Research*. 2001; **37**:3390-400.
- [5] Al-Husseini HJ. Study of phosphorus processing factories in some calcareous soils in Mosul Governorate [High Diploma Thesis]. Mosul, Iraq: University of Mosul, College of Agriculture and Forestry; 2013.
- [6] Al-Abdaliy RSA, Al-Rawe WSM. Effect of the incubation period on the availability of phosphorus in calcareous soils of different agricultural exploitation in Nineveh Governorate. *Journal of Survey in Fisheries Sciences*. 2023; **10**:4493-504.
- [7] Radwan SA, Shalaby MMH, Nada WA, EL-Ashry SM. Effect of added rock phosphate and compost on soil phosphorus fractions after different incubation periods. *Menoufia Journal of Soil Science*. 2020; **5**:149-57.
- [8] Brosnan JR, Brosnan ME. The sulfur-containing amino acids, an overview. *Journal of Nutrition*. 2006; **136**:1636-40.
- [9] FAO. FAO soils partial: Management of calcareous soils [Internet]. 2016 [cited 2024]; Available from: <http://www.fao.org/soils>.
- [10] Weidenfeld B. Sulfur application effects on soil properties in calcareous soils on sugarcane growth and yield. *Journal of Plant Nutrition*. 2011; **34**.
- [11] Black CA. Methods of soil analysis. Madison, WI: *American Society of Agronomy*; 1965.
- [12] Jackson ML. Soil chemical analysis. Englewood Cliffs, NJ: *Prentice-Hall*; 1958.
- [13] Bremner JM, Mulvaney CS. Nitrogen total-P. In: Black CA, editor. *Methods of Soil Analysis*. Agronomy; 1982. p. 595-624.
- [14] Pratt PF. Potassium. In: Black CA, editor. *Methods of Soil Analysis*. Agronomy; 1965. p. 1022-30.
- [15] Alobaidy SFA. Effect of the tillage system, type of organic matter and phosphorus on P availability, growth and yield of wheat (*Triticum aestivum* L) in a gypsiferous soil [MSc Thesis]. Tikrit, Iraq: University of Tikrit, College of Agriculture; 2022.
- [16] Yao GF, Kone B, Amani K, Bahan FML. Effects of calcium and magnesium on phosphorus availability in Ferralsols and rice production in forest zones of Côte d'Ivoire. *Journal of Agricultural Chemistry and Environment*. 2024; **13**:33-53.
- [17] Almusmar NAH. Evaluation of the application of compost and sheep manure on the residual effect of phosphorus from different phosphate sources on subsequent plant growth and yield [PhD Thesis]. Tikrit, Iraq: University of Tikrit, College of Agriculture; 2021.
- [18] Dayan AS. Effect of calcium carbonate, pH, mud, and organic carbon on soil phosphate sedimentation for some farms in Wadi Hadramout. *Hadramout University Journal of Natural and Applied Sciences*. 2017; **14**:179-90.
- [19] AL-Hamdany HMM. Effect of magnesium application on determination of phosphate fertilizer requirements for wheat plant (*Triticum aestivum* L.) in soils with different contents of gypsum [PhD Thesis]. Tikrit, Iraq: University of Tikrit, College of Agriculture; 2020.
- [20] Ingole AJ, Vaidya PH, Aundhakar AV, Ghode MK. Effect of moisture and calcium carbonate content on chemical properties of soil and yield of cotton in Nanded District of Maharashtra. *Journal of Pharmacognosy and Phytochemistry*. 2018; **7**:1971-6.
- [21] Saad TM, AL-Absawy MH. Kinetic release of phosphorus when adding different levels of phosphor and its fractionation in the soil. *Al-Muthanna Journal for Agricultural Sciences*. 2018; **6**:34-42.
- [22] AL-Magimia KH. H. Influence of tillage, organic matter, and phosphorus on soil phosphorus and carbon status and growth, yield of corn in gypsiferous soil [PhD

Thesis]. Tikrit, Iraq: University of Tikrit,
College of Agriculture; 2019.