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Study of Critical Density of Phosphorus and Its Various Forms in the Rice Fields Soil GILAN Cities

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Abstract: ***Critical density of phosphorus and its various forms in the rice field's soil Gilan city is important for biological and economic reasons. This study to determine the density of phosphorus and its various forms is performed in the rice field's soil Gilan cities. This research is used three methods of extraction Morgan and Olson and Soltanpour to determine the density of phosphorus and there are the two methods of improved extraction of Chang and Jackson and the method Hadley et al density of phosphorus and its various forms. 20 farm among field of study were selected that soil properties that influence resorbable phosphorus plan and other forms have most of the changes. Superphosphate trpil fertilizer added on farms choice 0 and 120 kg values in hectare and critical density of phosphorus extracts that a significant correlation showed with grain yield of rice was calculated by using the Kit - Nelson visual method. The lowest level for Olsen method was16, the method of Morgan 4/5 and for Soltanpour method was 3 Mg in GE of soil. Considering the good correlation Olsen extraction method with relative yield also cheaper and less time for testing, this method is recommended as the best method for the extraction of phosphorus and phosphate fertilizers in paddy fields of northern area. Based on geographic distribution of Gilan inorganic paddies covers 37/4% of total phosphorus with 60-1427/5 range and with 353 Mg in K gr average, about 66/6% of total phosphorus and organic with25-252 range and with 250 Mg in K gr average. Between Of the various forms of in organic phosphorus were, linked phosphorus to calcium (64%) is most and then linked phosphorus to iron (31/34%) and linked phosphorus to aluminum and soluble phosphorus (0/26). It should be noted that phosphorus usable shows with all forms of phosphorus at significant correlation in 5%. But the most influence accepts in order of the linked phosphorus to aluminum, Organic phosphorus, soluble phosphorus and finally linked phosphorus to calcium.***

Keywords: Phosphorus, Various Forms, Rice, GILAN.

1. Introduction

Phosphorus is most important factor limiting agricultural production after nitrogen in many parts of the world and Iran. Phosphorus resources are limited and it is possible to end [56]. Population and per capita increasing necessitated for agricultural products, especially rice, as well as the limitation of land under rice cultivation, the use of chemical fertilizers to restore the soil to provide nutrients essential for plant. Rice brings out phosphorus from soil production per ton of product 2-3 kg [71, 57].

When soluble phosphorus compounds are added to the soil, it becomes poorly soluble or insoluble forms and as a result of its use by plants reduced [12, 13]. Because phosphorus is unusable in soil, the reasons are two processes sediment and adsorption. It is believed that sediment occurred at high concentrations of phosphorus and adsorption occurs at lower concentrations. Different soil components that are role in surface absorption of phosphorus are include iron and aluminum oxides, organic matter, calcium carbonate and Silicate mineral of soil [45].

Many agricultural soils in Iran are high levels of phosphorus because fertilizer phosphorus consumed in recent years [32]. Phosphorus absorption in soil is fast in the early stages, then absorption of phosphorus is slow and phosphorus precipitates this stage for organic phosphate (low absorption for plant).

Over time consumable phosphorus broadcasts to mineral or remain on sites with high affinity but Linked with great power and or deposition in combination with low solubility. As a result extractable phosphorus reduced with extractor [22, 24]. Degree of sorption phosphorus depends in addition to environmental factors and soil characteristics also depends amount of used fertilizer.

Phosphorus become non-absorbable in alkaline soils with calcium and magnesium stabilized. Phosphorus in acid soils stabilized by iron, aluminum and non-absorbed [26].

As explained before, phosphorus chemistry in soils is very complex, since inorganic phosphorus can react with elements such as calcium, iron, aluminum and this becomes phosphates with the ability to discharge.

To determine the concentration of phosphorus in the soil was used, there are three methods that consist of Morgan, Olson and Soltanpour. A good juicer is that extracts to be able to simulate root activity. In addition to the extractor, the extraction is also important. There are some factors in this stage consist of soil to solution ratio, extraction time and shaking speed [40].

Olsen is the most common method of extraction of phosphorus in the world. the method is appropriate to predict a wide range of soil used phosphorus availability for plants. Olsen method

are more sensitive to soil buffering capacity compared with other methods [38]. Morgan method is benefit or soils that have a significant amount of calcium phosphate. But in Soils that calcium phosphate are low and aluminum and iron phosphorus are considered to be sources used Olsen is the preferred method [47]. Also Soltanpour is a versatile method of extraction. This method is good correlation with vegetation indices at low and high doses of calcium carbonate [58]. Critical levels of phosphorus can vary depending on experimental conditions, physiological age, plant tissue, plant type and feature soil and crop management will be different [55].

Table 1: Detail methods of biplane extraction to determine the different forms of phosphorus

Shaking time (Minute)	*Ratio of Suspension*	*extract ant*	*Shape of Phosphorus*	*Steps*
30	1:50	Molar1 NH4CL	soluble phosphorus	1
60	1:50	Molar0.5 NH4F	linked phosphorus to Aluminum	2
1020	1:50	Molar0.1 NaOH	linked phosphorus to iron	3
60	1:50	Molar 0.2 H2So4	linked phosphorus to calcium	4
1020	1:25	Molar 2H2So4	organic phosphorus	5

As well to determine the mineral phosphorus and the pursuit of self-transformation in fertilizers after application in soil used two of the modified method of Chang and Jackson [7] extraction and sequential extraction method by Hadley [19].

Chang and Jackson improved extraction methods are widely used for determination of soil phosphorus. Hadley et sequential extraction method is for the determination of different forms of phosphorus that during available phosphorus (phosphorus soluble and phosphorus extracted by sodium bicarbonate) and linked to calcium Phosphorus (extractable phosphorus by hydrochloric acid) and inorganic phosphorus bound to iron and aluminum (extractable phosphorus with sodium hydroxide). There is a bit of good and stable organic phosphorus.

the study of various forms of phosphorus is used to determine and interpret the relationships between form and phosphorus soil test results Sharply and Smith ; Hailin kawar ; Lopez-Pinriv; and adsorption and phosphorus cycle in soil Halford and Mtingli,; Sharply and Smith, Ryan and, Pena and Torrent, Saeed and Monji, Thompson, Annvek, Akhtar and et al. Beck Vsanchr Kulav and Tian , Study the effect of arable crop plants and McGill and cooland Griffin and et alStudy the effect of organic matter on various forms of soil [63,64,18,27,57, 20, 64, 51,46,20].

Samadi in their study of calcareous soils Australia that shows inorganic soil classified in six groups that consist of [60]: linked to calcium phosphorus (Ca-P), linked to aluminum phosphorus (AL-P), Apatite (Ca10-P), Octa calcium phosphate (Ca8-P), linked to iron phosphorus (Fe-P) and, phosphorus trapped inside iron oxides. Takchand and tumar [18] used The modified method of Chang and Jackson to assess the fate of phosphorus added to the soil and the effect on deformation characteristics of soil phosphorus in 28 regions of Haryana and Uttar Pradesh India alkaline soil and showed that deformation of added phosphorus to, Electrical conductivity phosphorus easy decreased logarithmically with increasing cation exchange capacity, active iron, organic carbon and available phosphorus in plants.

Salk and Cree [67, 56] were mentioned in examining the different forms of phosphorus in Bangladesh paddy fields of phosphorus in the form of phosphorus segregation linked with calcium to phosphorus, iron and aluminum linked to phosphorus, and the remaining phosphorus soluble organic phosphorus and expressed that rice plant receives in the soil required amount of phosphorus in the form of phosphorus, phosphorus iron and aluminum and eventually connects to calcium phosphorus. And discharge of phosphorus leads to mineralization of organic phosphorus and change sustainable forms. Rice plant supplied that nutritional content of phosphorus can attract in the soil indigenous sources of supply can only be stored in a variety of forms of phosphorus in the soil [11].

Various forms of phosphorus in soil can effect on soil fertility and usable phosphorus. Malakooti and Kavoosi declared Critical levels of available phosphorus in paddy fields to 12 milligrams per kilogram [60]. Continuous removal of phosphorus with low power consumption or not use of phosphate fertilizers in the paddies lands north of the country in recent years causes change and possible reduction is storage form of phosphorus in paddy soil. And this status assessment makes important stored phosphorus in paddy country soil. Explore different forms of phosphorus and an awareness of their situation will be effective on optimize the use of phosphorus fertilizer and reduce adverse environmental impacts.

2. Materials and Methods

In this study, 100 farm soil before the start of the season proper distribution take at throughout the province composite samples bottom 0-30 cm. samples were passed after drying in air a 2 mm sieve. Then the critical concentration of phosphorus and its various forms was studied. Density level forms of phosphorus was determined by a modified method of Chang and Jackson by Quo.

The method of extraction sequence, various forms of phosphorus was used by 1)1mM ammonium chloride for extraction of soluble phosphorus, 2)0.5 Molar Ammonium fluoride to extract of linked to aluminum phosphorus, 3)0.1 Molar Sodium to extract of linked to iron phosphorus, 4)0.2 Molar Sulfuric acid hydroxide to extract of calcium phosphorus, 5)2 Molar Sulfuric acid for extracting phosphorus (Table 1).

as well extraction of soil it's done for extracting phosphorus plant with three methods: 1) Olsen method includes with 0.5 Molar sodium bicarbonate extraction at pH=8.5 on 2.5 g of soil with a ratio of 1/20 and a half hours shake [43], 2) organ

method involves extraction with 0.52 Molar acetic acid and 0.72 Molar Sodium acetate extraction at pH=4.8 on 10 g of soil with a ratio of 1/5 and a half hours shake [73], 3)Soltanpour method involves extraction with 1 Molar ammonium bicarbonate and .0005 Molar Di-ethylene tri-amine penta-acetic acid at pH=7.6 on 10 g of soil with a ratio of ½. And calculation of descriptive statistics and statistical analysis of data was performed by using spss software.

Table 2. Descriptive statistics of the physical and chemical characteristics of the studied soils

Resorb able Potassium Mg/Kg	*Resorb able phosphorus Mg/Kg*	*Nitrogen*	*pH PH*	*Organic carbon*	*Steps*
257	48/50	0/378	6/73	3/48	1
175	45/10	0/422	3/38	3/91	2
211	36/20	0/261	7/16	2/06	3
163	27/80	0/167	7/43	1/18	4
258	25/30	0/246	7/26	2/23	5
294	27/80	0/168	7/22	1/43	6
132	22/50	0/246	7/31	2/15	7
211	22/30	0/287	6/96	2/37	8
94	19/80	0/181	6/22	1/54	9
136	18/80	0/332	6/72	3/02	10
141	17/80	0/456	6/67	5/25	11
118	16/70	0/226	6/68	2	12
206	15/80	0/266	7/10	2/46	13
117	14/20	0/163	7/33	1/69	14
127	13/80	0/281	6/73	2/72	15
288	13/50	0/151	7/44	2/14	16
164	11/40	0/172	7/05	2/05	17
138	11/10	0/475	6/99	4/53	18
137	10/90	0/255	7/17	2/24	19
106	6/50	0/181	7/41	1/56	20

Table 3. Descriptive statistics for all forms of phosphorus

Percent of total phosphorus	*Average*	*Changes of domain*	*Different forms of phosphorus*
62/6	353	60 – 1427/5	Mineral phosphorus kg/mg
37/4	211	25 – 525	Organic phosphorus kg /mg
0/26	0/556	0 - 12/5	Soluble phosphorus kg/ mg

3. Results and Discussion

The results of physical and chemical analyses were performed on soil samples shown in No Table.2 and various forms of total phosphorus No Table.3 as well as various forms of inorganic phosphorus No .Table 4.

The results show that the maximum amount of phosphorus extracted is by Olsen method and minimum amount has been results of by Soltanpour method. Based on available data phosphorus extracted are reducing by these methods: Soltanpour< Morgan< Olsen Table (5). Because of the different extracts amounts of phosphorus by different extraction methods is different mechanisms of various forms of phosphorus is extracted [67]. Time difference in extraction soil ratio in the solution extractor are affecting in the extractable phosphorus amount.

Method Soltanpour is extracting a small amount of phosphorus that the reason it is possible to extract a short time. Morgan

method is benefit for soils that are appropriate for a considerable amount of calcium phosphate, and the having a high buffering capacity, more appropriate method of estimating the amount of Olsen method is phosphorus in calcareous soils [59].

Table 4. Descriptive statistics for mineral phosphorus

Percent of mineral phosphorus	*Average*	*The most amount*	*Least amount*	*Various forms of inorganic phosphorus*
64	226	800	20	linked phosphorus to calcium kg/mg
31/34	220/6	590	0	linked phosphorus to iron kg/mg
4/4	15/63	130	0	linked phosphorus to Aluminum kg/mg

Correlation coefficients become of extracted phosphorus by different methods plant extracts and relative performance in Table 6.

Samii and Alksminaraiana [57, 47] reported meaningful correlation between extracted phosphorus by Olsen and the relative performance of the rice plant. In addition to the extraction of phosphorus shows in good correlation with the Olsen method plant responses to aerobic and anaerobic conditions [66]. Critical levels of phosphorus determination with different methods of extraction of rice plants grown in soils of the study show that in most soil which is less extractable phosphorus, the relative performance of the plant is too low. And more soil extractable phosphorus is high, the relative performance of the plant is high. The results showed that the critical level of P by Olsen, 16, of Morgan 4/5 and Soltanpour procedure is 3 mg per kg. The comparison numbers indicate that extracts which are extracted from the soil more phosphorus, which has a higher critical level. And vice versa extract the phosphorus less extract, they have a lower critical level. Thus, the critical level of Morgan and Soltanpour is less than the Olsen method because phosphorus have obtained. Guerra [16] reported critical levels of phosphorus by Olsen Juicer for rice plant 6/90 mg per kg, Rahman [49] reported critical levels of phosphorus by Olsen Juicer for rice plant 14 mg per kg and malakooti and kavoosi [31] reported critical levels of phosphorus by Olsen Juicer for rice plant 12 mg per kg.

Table 5. Phosphorus average extracted by using different methods

Average	*maximum*	*minimum*	*extracting*
21/63	48/5	6/5	Olsen
4/8	15	1/3	Morgan
2/94	6/8	1	Soltanpour

Descriptive statistics are different forms of phosphorus from soil samples showed that soluble phosphorus in the form of it has the highest coefficient of variation, which is linked with aluminum phosphate and iron phosphate is linked. The most of elongation was observed in soil solution phosphorus. Table (7). Top of elongation and the coefficient of variation is indicates a non-normal distribution of the variables studied.

Based on the results of various forms of phosphorus included Inorganic phosphorus by range 60- 1427/5 and averages 757 mm per Kg, 62/6 % Of total phosphorus by range 218- 1677/5 and average of 563 mg per kg. Also organic phosphorus (Org-P) with the range 25-525 and an average of 211milligrams per kilogram included about 37/4 percent of the total phosphorus.

Studied various forms of inorganic phosphorus, phosphorus linked to calcium (Org-P) is the range 20 - 800 and average of 226 milligrams per kilogram that it takes 62% of inorganic phosphate. Phosphorus linked to Aluminum (AL-P) and phosphorus linked to iron (Fe-P) were a wide range of changes. Phosphorus linked to Aluminum (AL-P) by range 0-130 and average of 15/63 mg per kg which makes up 4.4% of inorganic phosphate. And phosphorus linked to iron (Fe-P) by range 0-590 and average of 220/60 mg per kg which makes up 31/34% of inorganic phosphate.

Table 6. The relationship of P extracted by different extract ants and the relative performance of rice seed

r The correlation coefficient	*Equation*	*Method of extracting*
0/54**	Y = 0/937 x + 69/656	Olsen
0/41*	Y = 1/9835 x + 80/405	Morgan
0/51**	Y = 5/1598 x + 74/733	Soltanpour

Beck Sanchez [6] reported a 18-year-forwarding of status assessment of phosphorus in the soil of agricultural lands that phosphorus linked to Aluminum and iron are the dominant form of phosphorus for plant available access to phosphorus are required food. Sharply and Smith [63] stated changes in these two forms of phosphorus in the beginning and end growing season, also [57] believe that rich plant absorb the maximum amount required of phosphorus in paddy fields after phosphorus soluble phosphorus linked with iron and aluminum. Soluble phosphorus (Sol-P) is by range 0-12/5 and average of 0/556 mg per kg, concentration is negligible due to the lack of quantity. Griffin [16] believe that although increased any source of phosphorus soluble phosphorus in the soil increases quickly, but it is easy to access plant during the growing season, the changes are not significant [57]. Expressed soluble phosphorus is as a source of medium phosphorus absorption by plants and concentration is low and average soil at different depths is difference farms with no significant.

Comparison of different forms of phosphorus concentrations suggest that organic phosphorus and phosphorus linked with Calcium are highest average in the forms of phosphorus. Salk and Creek [56] the assessment effects of various forms of phosphorus fertilizers and manure in paddy fields Philippines showed that the organic phosphorus has been the highest

among the various phosphorus.one of the possible reasons for this type of high concentrations of phosphorus in paddy fields of the study area returns to less phosphorus absorption of rice plant of this source. Salk and Creek in considering the use of various forms of phosphorus as usable phosphorus to emphasize that anaerobic conditions caused flooding and limits the impact on microbial activity mineralization of organic phosphorus is a slow process with the process of organic phosphorus in the soil accumulates [56].

Table 7. Descriptive statistics of phosphorus in soil

Coefficient of Variation	*Elongation*	*Skewness*	*Average*	*maximum*	*minimum*	*Shape of Phosphorus*
9/4	2/217	1/629	19/93	88/2	1/3	Usable phosphorus kg /mg
4/7	0/172	0/637	211	525	25	Organic phosphorus kg/mg
6	1/569	0/939	226	800	20	linked phosphorus to calcium kg/mg
12	1/842	1/561	220/6	590	0	linked phosphorus to iron kg/mg
16/6	6/342	2/532	15/63	130	0	linked phosphorus to Aluminum kg/mg
27	19/968	3/822	0/556	12/5	0	Soluble phosphorus kg/ mg
6	5/259	1/802	353	1427/5	60	Organic phosphorus kg/ mg
4	5/232	1/602	563/70	1677	218	Total phosphorus kg/ mg

A believe to McGill and Cole only under circumstances where the addition of inorganic phosphorus in the soil is limited, the mineralization of organic phosphorus deficiency able to subjugate occurred phosphorus is needed for the plant. Thompson [66] and Akhtar [1] stated in the effect of soil organic matter the different forms of phosphorus that the addition of organic matter or soil organic matter in paddy fields is due to the high intrinsic increasing the concentration of dissolved phosphorus and organic phosphorus in soils. Although this figure of phosphorus not available for rice plant directly but is active biochemical and can be used after discharge phosphorus mineral plant to increase. The researchers stated because of the impact on the ability of the soil to stabilize the soil and keep the soil phosphorus, increased large pores and contribute to the greater mobility of phosphorus in the soil profile and biological activity of soil organisms live in the land paddy. Linear correlation with other forms of phosphorus and available phosphorus is shown in Table 8.

Most significant linear correlation is between usable phosphorus with phosphorus linked to aluminum (0.94) followed by phosphorus linked with iron (0.84). Linear correlation of phosphorus linked to Aluminum and iron is significant and strong (0.85). Also linear correlation of phosphorus linked to Aluminum and soluble phosphorus is significant and strong (0.73). Correlation other forms of phosphorus together is significant, but weak. Based on the coefficient of determination adjusted available phosphorus in soils affected is located by phosphorus, respectively linked with aluminum, organic phosphorus, soluble phosphorus and eventually phosphate linked to calcium. The different forms of phosphorus is justified 90% of usable phosphorus. Meanwhile linked phosphorus to Aluminum is capable contribution against other forms of phosphorus. This relationship suggests that perhaps these components can have a role in ensuring the plant available phosphorus.

Samadi and Jilkz [60, 61] reported that Australian soil phosphorus extractable by Olsen correlation method has linked phosphorus to Aluminum, phosphorus linked to iron, apatite, di calcium phosphate and total phosphorus. Lopz- Pynryv and Garsya- Navarro [49]. Reported that in the Spain available extraction phosphorus soils with 1 Molar ammonium chloride were significant correlation with linked phosphorus to Aluminum. Samavati and Hosseinpoor [62] reported that extractable phosphorus in soils of Hamadan Olsen method was a significant correlation with phosphorus linked to calcium, linked phosphorus to Aluminum, linked phosphorus to ironed soluble phosphorus. Due to the critical level of phosphorus in the most of paddy fields Gilan it seems available phosphorus in soils studied is high because the continuous fertilization and inactivity phosphorus in the soil, which increases the amount of phosphorus in the soil in these areas is essential, attributed as the source for compensation phosphorus is needed for plant. Salk and Creek reported that concentration of usable phosphorus increased in paddy land under saturation conditions and flooding. These changes are differences in the acidity of soil around plant roots cultivated rice. But since the plants cannot used all the available phosphorus, the soluble and resorb able phosphorus cause in pervade effect, go to places farther away from the roots to the soil, creating a more uniform distribution. On the other hand the indiscriminate use of phosphate causing conversion soluble orthophosphate to other form in recent years. According Quo [9] Changes in soil phosphorus concentrations is not unexpected in a region. Probably in this soils different levels of available phosphorus can exist because these use of phosphate fertilizers in soils with different speed conversion of soluble phosphorus in the form of with lower solubility. Salk shows that relatively young soils as Ainspti colls found more available phosphorus compared with more mature soil, because in mature soils such as Alti soils and soils with low pH become to less soluble forms due to the abundance of ions such as: Fe3+, AL3+ and resorb able phosphorus.

Table 8. The correlation coefficient in the various shapes of phosphorus in paddy soils of the region of interest

Usable phosphorus	*Soluble phosphorus*	*linked phosphorus to Aluminum*	*linked phosphorus to iron*	*linked phosphorus to calcium*	*Organic phosphorus*	*Shape of Phosphorus mg /kg*
- 0/35	- 0/139	- 0/25	- 0/28	- 0/051	1	Organic phosphorus
0/33	0/33	0/31	- 0/054	1	-	linked phosphorus to calcium
0/84	0/44	0/85	1	-	-	linked phosphorus to iron
0/94	0/73	1	-	-	-	linked phosphorus to Aluminum
0/84	1	-	-	-	-	Soluble phosphorus
1	-	-	-	-	-	Usable phosphorus

4. Conclusion

The results of this research Olsen extraction method is economic because it is speed of the extract and as well as the relationship acceptable to the relative performance of the rice plant is recommended as the most appropriate method to determine the critical level of phosphorus crop that the value of the method will be referred to as 16 milligrams per kilogram of soil. so soils that have higher levels of phosphorus critical level, do not have to use phosphate and vice versa soils that amount phosphorus are less critical level should be based on soil test is added phosphorus fertilizer. Of course most of studied soils was with higher phosphorus level critical. Base on the research was carried out by 353mg/kg means of inorganic phosphorus be included 62/6 percent of total phosphorus and organic phosphorus with 210 mg/ kg means phosphorus be included 37/4 percent of total phosphorus. As well among the forms of inorganic phosphorus were linked phosphorus to calcium with highest mean (226), followed by linked phosphorus to iron with mean (22/06) and linked phosphorus to Aluminum with mean (15/63) and soluble phosphorus. Coefficient variation of usable phosphorus Fig. of phosphorus in the studied soils were high. Linear correlation was observed between phosphorus and different forms of phosphorus. usable phosphorus were strong significant correlation with linked phosphorus to calcium, linked phosphorus to iron, linked phosphorus to Aluminum and soluble phosphorus that shows probly this form of phosphorus can be used as a source native in the supply of available phosphorus have a role. N the study area most affected will accept, linked phosphorus to Aluminum, soluble phosphorus, linked phosphorus to iron and ultimately linked phosphorus to calcium.

References

[1] Akhtar, M.S., Richards, B.K., Medrano, P.A., DeGroot, M., and Steenhuis, T.S.2003. Dissolved phosphorus from undisturbed soil cores: Related to adsorption strength, flow rate, or soil structure. Soil Sci. Soc. Am. J. 67: 458-470.

[2] Ahmad N and Jones RL, 1988. Forms of occurrence of inorganic phosphorus and its chemical availability in the limeston soil of Barvados. Soil Science 31: 184-188.

[3] Bakheit-Said, M., and Dakermanji, H. 1993. Phosphate adsorption and desorption by calcareous soils of Syria.Commun. Soil Sci. Plant Annal. 24: 197-210.

[4] Black CA, 1993. Soil Fertility Evaluation and Control. Lewis. Pub. Kansas State University USA.

[5] Bray RH and Kurtz LT, 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Science 59: 39-45.

[6] Beck, M.A., and Sanchez, P.A. 1994. Soil phosphorus fraction dynamic during 18 years of cultivation on a Typic Paleudult. Soil Sci. Soc. Am. J. 58: 1424-1431.

[7] Chang, S.C., and Jackson, M.L. 1957. Fractionation of soil phosphorus. Soil Sci. 84: 133-144.

[8] Cate RB and Nelson LA, 1971. A simple statistical procedure for partitioning soil test correlation data in to two classes. Soil Science 35: 658-660.

[9] Chapman H D and Pratt PE, 1982. Methods of Analysis for Soil Plants and Waters, University of California publ. No. 4034. Berkely, California.

[10] Colwell JD, 1963. The estimation of the phosphorous fertilizer requirements of wheat in southern new south wales by analysis. Australia. Journal of Agricultur and Animal Husbandry 3: 190-198.

[11] Dhillon, N.S., and Dev, G. 1988. Transformation of soil inorganic phosphorus reactions under various crop rotations. J. Indian Soc. Soil Sci. 39: 709-713.

[12] Dahnke WC and Olsen RA, 1990. Soil test correlation, calibration, and recommendation. Soil Science 24: 45-68.

[13] Dalal RC and Hallsworth EG, 1976. Evaluation of the parameters of soil phosphorus availability factors in predicting yield response and phosphorus uptake. Soil Science Society of America Jornal 40: 541-546.
[14] Griffin, T.S., Honeycutt, C.W., and He, Z. 2003. Changes in soil phosphorus from manure application. Soil Sci. Soc. Am. J. 67: 645-653.
[15] Gee GW and Bauder JW, 1986. Particle size analisis., Pp. 383-411. In: Klute, A. (ed.) Methods of Soil Analysis. Part l. Soil Science Society of America. Madison, WI.
[16] Guerra AL, Mndoza RC and Beltran R, 1989. Phosphorous and the establishment of critical levels for rice in a ferralitic soil of Camagury Province. Ciencia Teknica en la Agricultura 12: 67-73.
[17] Guilford DE, Chandler WV and Bryan OC, 1970. Effect of phosphorus applications to Lakeland sands on pineapple arrange yields, available soil phosphorous, and leaf phosphorous. Soil Science of America 2: 26-29.
[18] Hailin, Z., and Kovar, J.L. 2000. Phosphorus fractionation. P 50-59, In: Methods of P Analysis. (ed.). USDA /ARS. Ames, IA.
[19] Hedley, M.J., Stewart, J.W.B., and Chuhan, B.S. 1982. Changes in inorganic and organic soil phosphorous fractions induced by cultivation practices and by laboratory incubations. Soil Sci. Am. J. 46: 970-976.
[20] Halford ICR, 1980. Greenhouse evaluation of four phosphorous Soil tests in relation to phosphate buffering and labile phosphate in soils. Soil Science Society of America Journal 44: 555-559.
[21] Holford, I.C.R., and Mattingly, G.E.G. 1975. The high– and low-energy phosphate adsorption surfaces in calcareous soils. J. Soil Sci. 26: 407-417.
[22] Javid S and Rowell DL, 2002. A laboratory study of the effect of time and emperature on the decline in Olsen P following phosphate addition to calcareous soils. Soil Use Mang 18: 127-134.
[23] Klute, A. 1985. Methods of soil analysis .Part I and II .Agronomy. Mad. Wis. USA, 1188p.
[24] Kolawole, G.O., and Tian, G. 2007. Phosphorus fractionation and crop performance on an alfisol amended with phosphorus rock combined with and without plant residues. Afr. J. Biotech. 6: 16. 1972-1978.
[25] Kuo, S. 1996. Total organic phosphorus. P 869-919, In: Methods of Soil Analysis. Sparks, D.L. (ed.), Part 3. Chemical Methods. SSSA. Madison, WI.
[26] Kover JL and Barber SA, 1988. Phosphorous supply characteristics of 33 soils as influenced by seven rates of phosphorous adition. Soil Science Society of America Journal. 52: 160-165.
[27] Lopez-Pinerio, A., and Garcia-Navarro, A. 2001. Phosphate fractions and availability in vertisols of South-Western Spain. Soil Sci. Soc. Am. J. 166: 548-556.
[28] Laegreid M, Bockman OC and Kaarstad O, 1999. Agriculture, Fertilizer, and the Environement. Norsk hydro ASA. CABI Publishing, Porsgrunn, Norway.
[29] Laxminarayana K, 2003. Determination of available phosphorus by iron oxid impregnated filter paper soil test for Rice. Indian Journal of Agricultural Sciences 73: 684-687.
[30] Mahmoud Soltani, Sh., and Samadi, A. 2003. Phosphorus fractionation of some calcareous soils in Fars province and their relationships with some soil properties. Agr. Sci. Nat. Res. J. 3: 7. 119-128.
[31] Malakooti, M.H., and Kavoosi, M. 2004. Balance nutrition of rice. Sena Pub. Iran, 611p. (In Persian)
[32] Maftoun M, Hakimzadeh Ardekani MA, Karimian N and Ronaghi MA, 2003. Evaluation of phosphorous availability for paddy rice using eight chemicalsoil tests under oxidized and reduced conditions. Communications in Soil Science Plant Analysiysis 34: 2115-2129.
[33] Mascagni HJ and Cox FR, 1985. Calibration of a managanese availability index for soybean soil test data. Soil Science Society of Ameraca Journal 49: 382-386.
[34] Mclean EO, 1982. Soil pH and lime requirement. Pp. 1151-1165. In: miller RH and Keeney DR (eds). Methods of Soil Analysis. Part2. Chemical and microbial properties. Soil Science Society of America, Madison, WI.
[35] Mehlich A, 1984. Mehlich 3 soil test extractent: A modification of Mehlich 2 extractent. Communications Soil Science and Plant Analysis 15: 1409-1416.
[36] McGill, W.B., and Cole, C.V. 1981. Comparative aspects of cycling of organic C, N, S, and P through soil organic matter. Geoderma, 26: 267-286.
[37] Murphy, I.C.R., and Riley, J.P. 1962. A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta. 27: 31-143.
[38] Menon RG, Chien SH and Hammound LL, 1990. Development and evaluation of the Pi soil test for plant-available phosphorous. Communications in Soil Science and Plant Analysis 21: 1131-1150.
[39] Morgan MF, 1937. The Universal Soils Test System-Uni. Connecticut Agricaltural Exepriment Sattion. Wiley, New york.
[40] Munter RC, 1988. Laboratory factors affecting the extractability of nutrients. Pp. 115-134. In Dahnke WC (ed). Recommended Chemical Soil Test Procedures for the North Center Region. Soil Science Society of America, Madison,WI.
[41] Nwoke, O.C., and Vanlauwe, B. 2003. Assessment of labile phosphorus fractions and adsorption characteristics in relation to soil properties of West Africa savanna soils. Agriculture, Ecosystems and Enviroment, 100: 285-294.
[42] Nelson LA and Sommers LE, 1990. Total carbon, organic carbon, and organic matter., Pp. 539-579. In: Martell AE and Smith RN (eds). Methods of Soil Analysis. Part 2. Soil Science Society of America, Madison, WI.
[43] Olsen SR, Cole CV, Watanabe FS and Dean CA. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. Soil Science Society of America 21: 144- 149.
[44] Olsen, S.R., and Sommers, J.F. 1982. Phosphorus. P 403-430, In: A.L. Page (ed.), Methods of soil Analysis. Agron. No. 9, part 2: Chemical and microbiological properties, 2nd edition, Am. Soc. Agron., Madison, WI, USA.
[45] Olsen, S.R., and Khasawneh, F.E. 1980. Use and limitation of physicalchemical criteria for assessing the state of phosphorus in soils. P 361-404, In: The Role of Phosphorus in Agriculture. (eds.), Khasawneh, F.E.,

Sample, E.C., and Kamprath, E.J. 361-404. Pub SSSA. Madison, WI.
[46] Pena, F., and Torrent, J. 1990. Predicting phosphate sorption in soils of Mediterranean regions. Fertil Res. 23: 173-179.
[47] Pierzynski GM, 2000. Methods of phosphorus analysis for soils. Sediments, residuals, and water. Kansas state university.Southern cooperative series buletine No. 396: 1073-1081.
[48] Prasad R and Power SF, 1997. Soil Fertility Management for Sustainable Agriculture. CRP. Press. Pp. 293-312. Wiley, New York.
[49] Rahman GK, Jahiruddin M And Haque MQ, 1995. Effect of soil properties on the extraction of phosphorous and its critical limit for rice. Journal of the Indian Society of Soil Science 43 ; 67- 71.
[50] Reddy, D.D., Rao, A.S., and Rupa, T.R. 2000. Effects of continuous use of cattle manure and fertilizer phosphorus on crop yields and soil organic in a Vertisol. ioresource Technol. 75: 113-118.
[51] Ryan, J., Curtin, D., and Cheema, M.A. 1985. Significance of iron oxides and calcium carbonate particle size in phosphate sorption by calcareous soils. Soil Sci. Soc. Am. J. 48: 74-76.
[52] Samiei A and Bhajan S, 1987. Evaluation of air-dry and submerged soil samples for measuringcritical available phosphorous levels in alkalin wetland rice soils. Soil Science 35: 58-62.
[53] Sen Gupta TM and cornfield AH, 1962. Phosphorous in calcareous soils. III. Available phosphorous in calcareous soils as measured by five chemical methods and phosphate uptake rye grass in a pot test. Journal of Science Food Agrie 14: 567-567.
[54] Sarawat KL, Jones MP, Diatta S. 1997. Extractable phosphorous and rice yield an Ultisol of the humid forest zone in west Africa. Communications in Soil Science and Plant Analysis 27: 281- 294.
[55] Simard RR and Tran TS, 1993. Evaluation plant-available phosphorous with- the electroultrafiltration technique. Soil Science Society of America Journal 57: 404-409.
[56] Salardini, A. 1995. Soil fertility. Tehran University Pub. Iran, 441p. (In Persian)
[57] Saleque, M.A., Adedin, M.J., Ahmed, Z.U., Hasan, M.A., and Panaullah, M.2001. Influences of phosphorus deficiency on the uptake of nitrogen, potassium, calcium, magnesium, sulfur, and zinc in lowland rice varieties. J. Plant Nutr. 24: 1621-1632.
[58] Saleque, M.A., and Krik, G.J. 1995. Root-induced solubilization of phosphorus in the rhizosphere of lowland rice. New Phytol. 129: 325-336.
[59] Saleque, M.A., Nahar, U.A., Islam, A., Pathan, A.B.M.U., and Hossain, T.M.S.2004. Inorganic and organic phosphorus fertilizer effects on the phosphorus fractionation in wetland rice soils. Soil Sci. Soc. Am. J. 68: 1635-1644.
[60] Samadi, A., and Gilkes, R.J. 1999. Phosphorus transformations and their relationships with calcareous soil properties of south Western Australia. Soil Sci. Soc. Am. J. 63: 809-815.
[61] Samadi, A., and Gilkes, R.J. 1998. Forms of phosphorus in virgin and fertilized calcareous soils of Western Australia. Austral. J. Soil Res. 36: 585-601.
[62] Samavati, M., and Hossainpoor, A. 2006.Phosphorus fractionation of some soils in Hamedan and their relationships with some soil properties.Soil and water J.20: 2. 246-259.
[63] Sharpley, A.N. 1985. Phosphorus cycling in unfertilized and fertilized agricultural soils. Soil Sci. Soc. Am. J. 49: 905-911.
[64] Sharply, A.N., and Smith, S.J. 1985. Fractionation of inorganic phosphorus in virgin and cultivated soils. Soil Sci. Soc. Am. J. 49: 127-130.
[65] Sui, Y., and Thompson, M.L. 1999. Fractionation of phosphorus in a Mollisol amended with biosolids. Soil Sci. Soc. Am. J. 63: 1174-1180.
[66] Sui, Y., and Thompson, M.L. 2000. Phosphorus sorption, desorption, and buffering capacity in biosolids-amended molisol. Soil Sci. Soc. Am. J. 64: 164-169.
[67] Singh B, Arora BR and Sharma KN, 1996. Evaluation of Pi soil test for extraction of available phosphprus in soils for maiz. Indian Society Soil Science Journal 44: 165-167.
[68] Soltanoour PN and Schwab AP, 1977. A new soil test for simultaneous extraction of macro and micro nutrients in alkalin soils. Comunication in Soil Science Plant Analysis 8: 195-207.
[69] Tyler, G. 2002. Phosphorus fractions in grassland soils. Chemosphere,
[70] TekChand, A., and Tomar, N.K. 1993. Effect of soil properties with phosphate fixation in some alkaline calcareous soils. J. Indian. Soc. Soil Sci. 41: 56-61.
[71] Timsina, J., and Connor, D.J. 2001. Productivity and management of rice-wheat ropping systems: Issues and challenges.Field Crop Res. 69: 9.

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