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RELATIVE EFFICIENCY OF FE-OXIDE STRIP FOR EXTRACTING PHOSPHORUS IN SOME EGYPTIAN SOILS

El-Gendi, S.A., A. Sh. A. Osman, S.M.M. Allam and M.E. Abdallah
Soil, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt.

ABSTRACT

Three methods for extracting available phosphorous in some Egyptian soils, has been compared with Fe-strip method which proposed by Tzy-Huei Lin et al. (1991). Moreover, to provide a base of comparison, a biological treatment was also established.

The results showed that the highest total-P value was recorded for clay soils (1943 mg kg^{-1}), followed by calcareous soil (848.55 mg kg^{-1}) and sandy soils (627.4 mg kg^{-1}). Amongst the tested soil properties, the statistical analysis revealed that only clay content (r= 0.696**) and calcium carbonate content (r = -0.601*) were significantly correlated with the total-P.

The data showed that the extracted P percent (from its total) by the tested extractants may be ranked as follows; Soltanpour and Schwab (5.56%) > Fe-strip (1.3%). While Bray1 and Olsen and Sommers methods released minor portion of P. the high P portion extracted by Soltanpour and Schwab may be due to 1) a particular affinity between DTPA and P, 2) this extractant may released various pools of P beside the available portion into solution and 3) the effect of high ionic strength (1M) of NH_4HCO_3.

The data also showed that the percent of P released from calcareous soils > sandy soils > clay soils. This may be attributed to the employed methods that may destroy a number of P-minerals in calcareous soils, consequently the recovery % of P increased. While the minor percent of P released from clay soil may be attributed to its highly adsorptive power in that soil. The statistical results showed that Fe-strip was significantly correlated with the widely used soil extractants (r= 0.451*).

The results of biological evaluation of the tested methods indicated that only Fe-strip (M_4) ad Olsen and Sommer method (M_3) were significantly correlated with the amount of P-uptake by plants. The regression equations for this relation were:

$Y = 12.29 + 0.94\ X$ $R^2 = 19.9$

$Y = 15.30 + 4.86\ X$ $R^2 = 19.6$, respectively.

These results concluded that Fe-strip method was satisfactory and gave reliable information about available P for plat.

INTRODUCTION

Because of the vital role of phosphorous in plant nutrition and the variable reactions which take place when it is incorporated into the soil, it is of great interest to know the soliss content of that element. However, in many cases the total content is of little biological or ecological interest (Alvo, 1993; Saker, 1995 and Jones, 1998).

Several extracting solutions (e.g., Olsen, 0.5 M $NaHCO_3$, pH 8.5; Bray I, 0.025 M HCl + 0.03 M NH_4F; Bray II, 0.03 M NH_4F + 0.1 M HCl; Mehlich III, 0.5M HCl +0.0125 M H_2SO_4; and Kelowna, 0.25 N HOAC + 0.015 N NH_4F) were used to extract the available-P pool. These extractants react with the soils through one or more of the following mechanism; chelating,

hydrolysis, complexing, and solubility. On other side, it is impossible to find an extraction that releases a definite pool of a concern metal. Furthermore, it needless to say that is impossible to find an extractant that releases in most types of soils a definite fraction of an element.

Fe-Oxide impregnated filter paper strips, is a new technique proposed by Tzu-Huei Lin et al. (1991) for determination the availability of P. they stated that this method simulates the mechanism of P released from solid phase to rhizosphere and gave reliable prediction about the availability of P in soil. Moreover, Maguire et al. (2000) reported that Fe-strip method was useful for measuring the initial potential for soils to release P.

MATERIALS AND METHODS

Twenty surface (0-20 cm) soil samples varied in some of their properties were selected from some locations in Egypt. These samples were air dried, crushed, sieved and analyzed for general identification as outlined by Black (1965) and Page (1982). The range and mean values of their chemical and physical properties are listed in Table 1.

Table 1. Range and mean values of some physical and chemical properties of the tested soils.

Soil property	Range	Mean
PH (1: 2.5 soil water suspension)	7.2 - 8.3	7.84
EC (dS/m in soil paste extract)	1.0 – 16.8	5.75
Organic carbon %	1.02 – 3.35	1.93
Total calcium carbonate %	0.40 – 36.80	9.24
Clay %	0.12 – 76.32	13.07
Total P (mg/kg): Sandy soil	356 – 898	529.4
Calcareous soil	514.2 – 957	848.55
Clay soil	1267.4 – 2118.23	1943.0

The tested procedures for extracting-P

Four soil procedures were compared to extracting the available portion of P:

1) Ammonium bicarbonate + DTPA, (1 M NH_4HCO_3 + 0.005 M DTPA, pH 7.6), as described by Soltanpour and Schwab, 1977 denoted as M_1.
2) Bary1, (0.03 NH_4F + 0.025 N HCl), Bray and Kurtz, 1945 denoted as M_2.
3) Distilled water,as outlined by Olsen and Sommers,1982,denoted as M_3 and
4) Fe-Oxide strips, as described by Tzu-Huei Lin et al., 1991 denoted as M_4. This technique based on immersing filter paper in 0.4M $FeCl_3$ solutions and in 2.7 M NH_4OH solution, respectively to convert $FeCl_3$ into the oxide form, washed, dried and stripped into 2x10 cm.

Extraction of soil-P by paper strip method:

The tested soil was equilibrated with 0.01 M $CaCl_2$ in (1:40) soil-solution ratio. Four paper strips were attached to the cap of the shaken bottle. The bottle was shaken for 16 h at room temperature. Afterwards, the strips were removed, washed in distilled water. To extract available P, the strip was

shacked with 40 ml of 0.2 M H_2SO_4 for one hour in a polyethylene bottle. The concentration of P in the solution was determined calorimetrically using ascorbic acid method according to Hergert (1970).

Biological evaluation:

To evaluate the effectiveness of the tested extractants for determination availability of phosphorous, a plant reference (Barley, *Hordeum vulgare L*) was pot planted in the tested soils. At the end of growth period, (60 days), the plants were cut, dried, weighted and grounded. A 0.2 gm of each plant material was wet digested according to Chapman and Pratt (1961) and P uptake was calculated as mg/ plant. The obtained data were statistically analyzed according to Barbara and Brain (1994).

RESULTS AND DISCUSSION

Values of total P in the tested soils were listed in Table 2. The data revealed that the highest total-P values were recorded for alluvial soils followed by calcareous and sandy soils. The range of total-P in mg kg^{-1} (1267.4 to 2118.23); (514.2 to 957) and (356 to 898.2) in alluvial, calcareous and sandy soils, respectively. These data were almost within the ranges reported by Balba (1981) for some soils of Egypt.

Table 2. The P concentration (in ppm) extracted by the various tested methods and total P content.

Sample No.	M_1	M_2	M_3	M_4	Total P (mg kg^{-1})
1	11.69	3.47	1.50	10.43	1654.60
2	27.23	8.97	2.51	14.69	1614.20
3	13.52	6.52	1.61	10.24	1437.80
4	11.67	3.64	2.28	14.03	1435.00
5	46.59	1.28	1.02	8.69	418.00
6	9.91	3.37	1.43	8.92	1769.20
7	12.68	1.69	1.21	9.04	681.60
8	23.17	1.97	0.95	8.95	1416.00
9	9.91	5.27	2.28	13.77	954.00
10	34.34	8.13	1.70	10.25	1620.00
11	1.90	2.15	0.95	10.46	1712.00
12	26.36	2.42	1.61	10.74	1519.00
13	11.14	3.37	0.95	9.40	1610.00
14	25.58	3.00	1.06	9.49	1518.00
15	19.01	2.08	0.95	7.58	534.00
16	61.97	2.20	0.95	9.24	598.20
17	64.07	5.43	1.94	11.35	651.00
18	56.17	1.14	1.06	10.56	643.00
19	37.40	5.56	1.51	9.43	496.00
20	74.90	2.41	1.93	10.45	514.00
$\bar{X}$	28.96	3.70	1.47	10.39	1139.65

The effect of the tested soil properties on total-P contents was statistically illustrated in Table 3. It was obviously cleared from the table that only clay content and calcium carbonate were contributed significantly with total-P. The statistical analysis showed highly positive relation between clay and total-P ($r = 0.696^{**}$), while calcium carbonate was correlated negatively ($r=-0.601^{*}$). Similar observations were also reported by Helal (1993).

Table 3. Simple correlation coefficient between the tested methodology for P and some of soil properties.

Soil property	M_1	M_2	M_3	M_4	Total P (mg kg^{-1})
EC	0.189	-0.321	-0.344	-0.120	-0.241
PH	0.416	-0.311	-0.111	0.238	-0.251
Clay	-0.567*	0.104	0.034	-0.038	0.696**
CaCO3	0.606*	-0.267	-0.229	0.173	-0.601*
O.M.	-0.244	0.165	0.388	0.175	0.305

The recovery of P calculated as percentage of its total by the tested extractants was illustrated in Fig.1. The data in Fig.1 showed that more than 5.56% (on average) was extracted with Soltanpour and Schwab method, like wise 1.32% was extracted by Fe-Strip method. Also, relatively small portions of P were extracted either with Bary and Kurts or Olsen and Sommers method. The recovery was 0.19 and 0.42% of P_t, respectively.

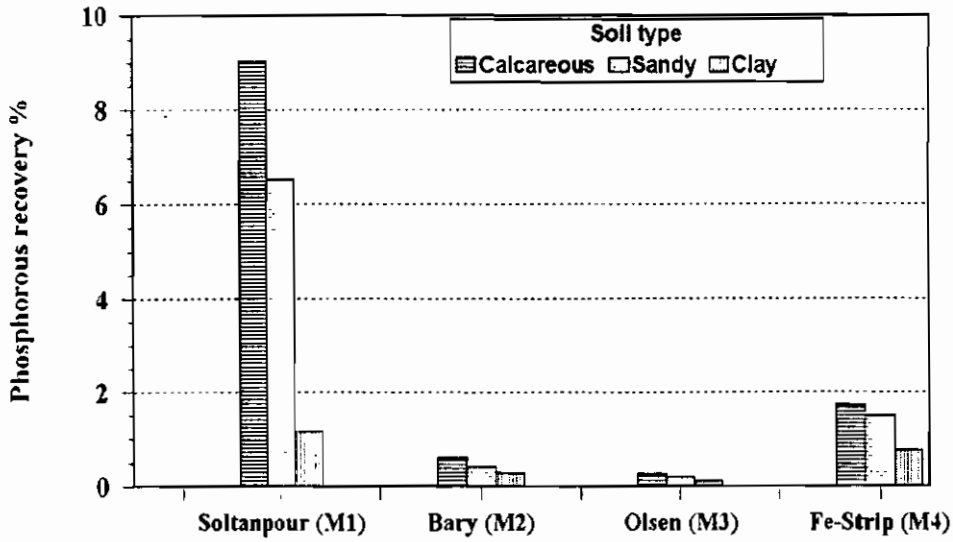

Fig. (1). Relation between the tested extractant and phosphorous recovery percent.

The efficiency of DTPA-NH_4HCO_3 solution (Soltanpour and Schwab, 1977) for extracting P may be due to a particular affinity between DTPA and P but may also be caused by the fact that this extraxtant apparently brought

much of organic P into solution, as well as, the effect of high ionic strength of NH_4HCO_3, 1M.

The influence of the soil type on P extractability was also illustrated in Fig.1. The results revealed that the values of P extracted with Soltanpour and Schwab solution were; 9.01, 6.51 and 1.16% of total-P in calcareous, sandy and clay soils, respectively. The corresponding values for Fe-Strip were; 1.72, 1.49 and 0.74%, respectively. The high portion of P released from calcareous soil compared with the others, probably due that the employed extractants might destroy P-bearing minerals in calcareous soil, consequently, transfer a number of components from the crystal structure of less resistant mineral into solution.

On the other side, the minor portions of P released from clay soil may be attributed to its high adsorptive power. This finding may be confirmed with the negative correlation obtained between P extracted in M_1 extractant and clay content values (r=-0.567), Table 3.

One of the goals of the research was to quantify the relationships between the included methods for testing availability of phosphorous. The data presented in Table 4 showed that M_4 method (Fe-strip) was significantly correlated with the widely used procedure M_1 (Soltanpour and Schwab). Furthermore, Fe-strip method was ease in use, don't causing losing in sample weight during shaking as well as it simulates the mechanism of P released from solid phase into solution.

Table 4. The correlation coefficients between the tested procedures and P-uptake

Extractant	M_1	M_2	M_3	M_4
M_2	-0.088			
M_3	0.035	0.680		
M_4	0.451	0.262	0.276	
Total-P	-0.580	0.379	0.161	0.074

Biological evaluation of the tested methods

The relation between the tested methods for extracting P and uptake-P by the reference plant (barely) was demonstrated in Fig. 2 (a-d). The data presented in the figure indicated that Olsen & Sommers (M_3) and Fe-Strip (M_4) were the only methods correlated significantly with the P-uptake by barely plants. Also, the regression equations obtained between P-uptake by barely and amounts of extractable-P by Olsen & Sommers and Fe-Strip were

$Y= 15.3+ 4.86X$ $R^2 = 19.6\%$

$Y = 12.59+ 0.94X$ $R^2 = 19.9\%$, respectively.

From the above results, it appears that the widely used soil method, (Soltanpour and Schwab, 1977) did not extract available P very precisely but it extracted many pools of P beside the available portion and could err greatly in predicting the uptake of P by plants. Meanwhile, Fe-strip method was satisfactory and gave reliable prediction for available P.

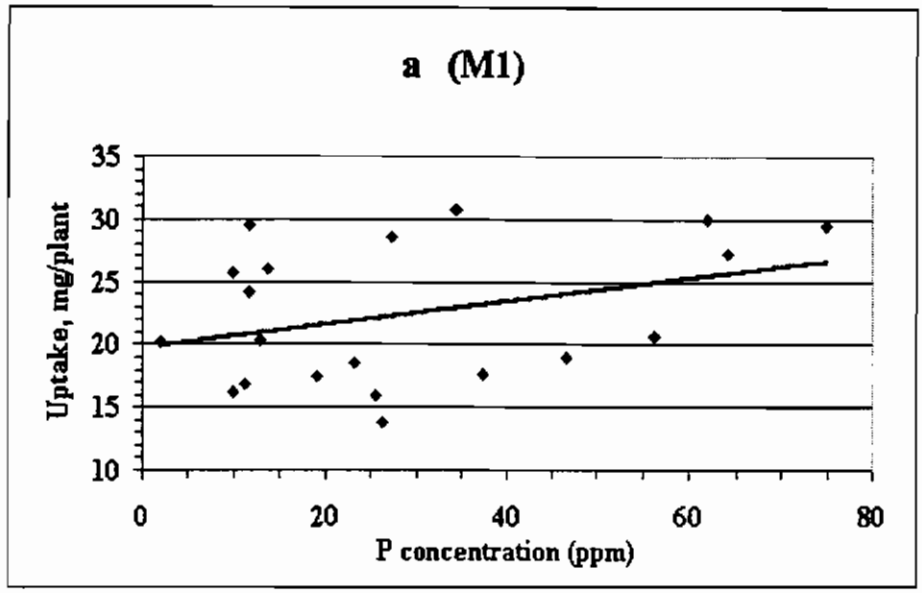

Fig. (2a). Relation between extracting phosphorous and P-uptake by barely plant.

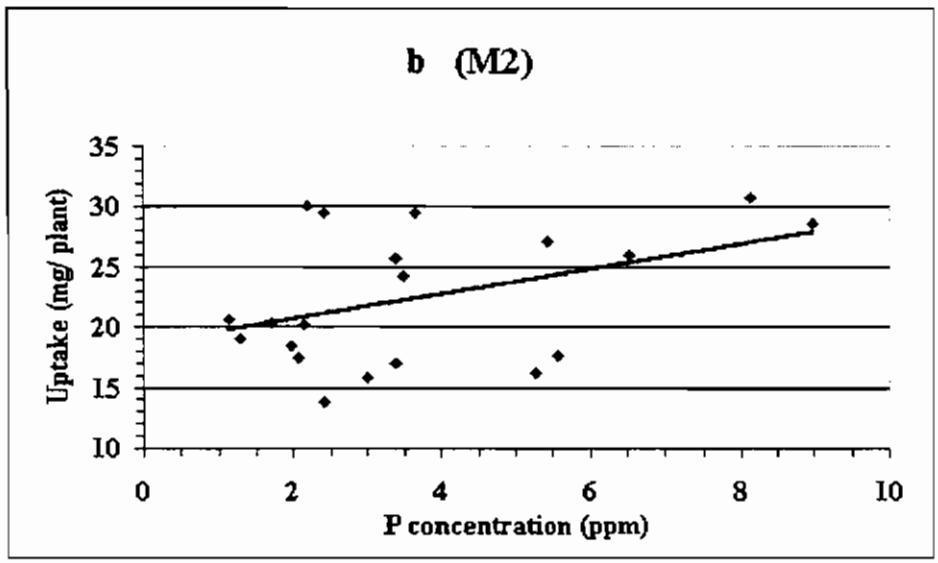

Fig. (2b). Relation between extracting phosphorous and P-uptake by barely plant.

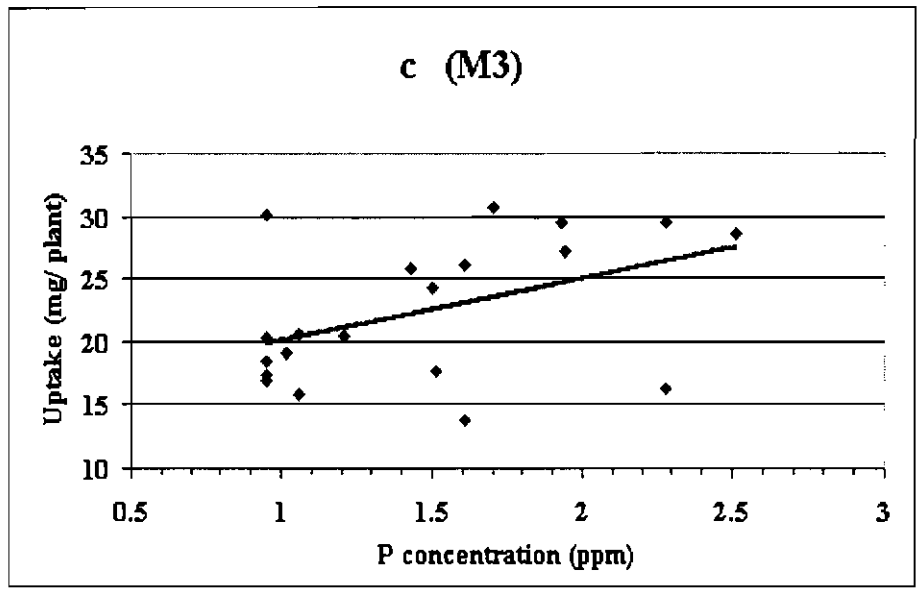

Fig. (2c). Relation between extracting phosphorous and P-uptake by barely plant.

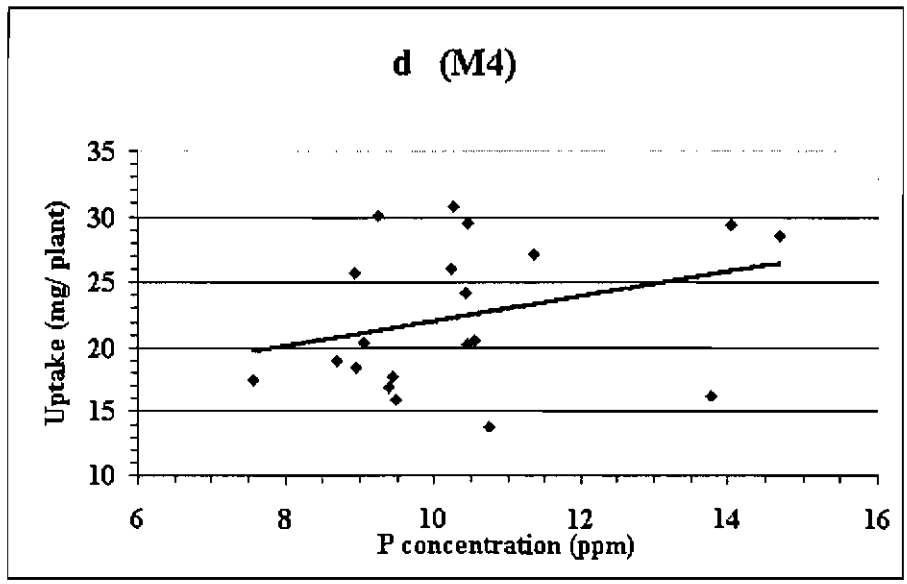

Fig. (2d). Relation between extracting phosphorous and P-uptake by barely plant.

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الكفاءة النسبية لاستخلاص الفوسفور الميسر باستخدام طريقة أشرطة ورق الترشيح المشبع بأكاسيد الحديد من بعض الأراضى المصرية

سمير عبدالظاهر الجندى، على شحاتة على عثمان، سيد محمد محمود علام و محمد السيد عبدالله
معهد بحوث الأراضى والمياه والبيئة- مركز البحوث الزراعية- شارع الجامعة- الجيزة- مصر

يهدف هذا البحث الى مقارنة ثلاثة طرق تستخدم فى استخلاص الفوسفور الميسر فى بعض الأراضى المصرية وبين طريقة أشرطة ورق الترشيح المشبع بأكاسيد الحديد والتى اقترحت سنة ١٩٩١ بمعرفة Tzy-Huei Lin et al . وحتى يكون هناك مستوى للمقارنة تم زراعة نبات الشعير لتتبع كمية الفوسفور الممتص.

أوضحت النتائج أن الفوسفور الكلى كان أعلى ما يمكن فى الأراضى الطينية (١٩٤٣ ملليجرام/كجم) يليها الأراضى الجيرية (٨٤٨,٥٥ ملليجرام/كجم) ثم الأراضى الرملية (٦٢٧,٤ ملليجرام/كجم). كذلك أوضحت النتائج أن من بين خصائص التربة المدروسة كان كل من محتوى الأرض من الطين (r=0.696**) وكذلك المحتوى الكلى من كربونات الكالسيوم (r=-0.601*) ترتبطان معنويا مع محتوى الكلى للفوسفور فى الأراضى. ويمكن ترتيب النسبة المئوية للفوسفور المستخلص بواسطة الطرق المدروسة (كنسبة من الكمية الكلية) كما يلى Soltanpour and Schwab (5.56%) > Fe-strip (1.30%). بينما كانت الكمية المستخلصة بواسطة Bray 1 أو بواسطة Olsen and Sommers ضئيلة جدا. وقد ترجع إزدياد النسبة المستخلصة من الفوسفور بواسطة طريقة Soltanpour and Schwab الى ١) وجود نوع من الأرتباط بين DTPA وبين الفوسفور، ٢) هذا المستخلص يمكن له أن يستخلص صور متعددة من الفوسفور بخلاف الصورة الميسرة ٣) قد يرجع ذلك الى زيادة القوة الأيونية للمستخلص (١ مولر) من NH_4HCO_3 . أوضحت النتائج كذلك أن النسبة المستخلصة من الفوسفور (بالنسبة للمحتوى الكلى) كانت أعلى فى الأراضى الجيرية بالمقارنة بالأراضى الرملية ثم الأراضى الطينية على الترتيب. وقد يرجع ذلك الى أن المستخلصات المدروسة قد تؤدى الى هدم العديد من المعادن الحاملة للفوسفور فى الأراضى الجيرية مما يؤدى الى إنفراد الفوسفور فى المحلول. أما فى الأراضى الطينية فيرجع صغر النسبة المستخلصة من الفوسفور الى القوة الادمصاصية العالية لتلك الأراضى. وقد أوضحت نتائج التحليل الاحصائى أن طريقة استخلاص الفوسفور بواسطة شرائط ورق الترشيح المبلل بأكاسيد الحديد (M_4) كانت مرتبطة معنويا مع طريقة Soltanpour and Schwab والمستخدمة على نطاق كبير (r=0.451*) كمستخلص للعناصر الميسرة فى التربة.

وقد أوضحت نتائج التقييم البيولوجى أن طريقتى M_4 وكذلك M_3 كانتا أكثر الطرق المدروسة ارتباطا بالكمية الممتصة من الفوسفور بواسطة نبات الشعير وكانت معادلات الانحدار كالآتى:

$Y = 12.59 + 0.94X$ $(R^2 = 19.9\%)$
$Y = 15.3 + 4.86X$ $(R^2 = 19.6\%)$

على الترتيب. وبالتالى تدل هذه النتائج على أن الفوسفور المستخلص بواسطة شرائط ورق الترشيح المبلل بأكاسيد الحديد (M_4) تعطى نتائج معقولة ومنطقية عن الفوسفور الميسر للنبات.