

# IMPROVING THE EFFECTIVENESS OF PR THROUGH COMBINING WITH ORGANIC MATERIALS AND MIXING WITH TSP IN TWO CALCAREOUS SOILS I.DIRECT EFFECTS <sup>+</sup>

تحسين فاعلية الصخر الفوسفاتي بإضافة المواد العضوية والمزج مع TSP في تربتين كلسية  
التأثيرات المباشرة

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## Abstract:

A pot experiment was conducted to determine the role of organic materials (peat and sludge) applied with phosphate rock (PR) and partial acidulation of PR (through mixing with a water soluble P fertilizer (TSP) in different ratios 50:50 and 60:40 TSP: PR) on effectiveness of PR (Dry weight, P uptake, NaHCO<sub>3</sub>-P, and water soluble P). Corn "maize" (*Zea mays* L. var. Rabee) was used as a test crop in two soils, medium and fine textured soils. Effects of treatments on some soil properties like water soluble Ca, EC, and pH was studied too. Results showed that 60TSP +40PR treatment was superior in dry weight of corn and NaHCO<sub>3</sub>-P followed by 50TSP+50PR treatment with no significant differences, while PR treatment was superior in P concentration in plant and P uptake followed by PR +sludge treatment with no significant differences. The 50TSP+50PR treatment gave the highest values of water soluble P and the lowest values of water soluble Ca, EC, and pH. The main effect of texture was for the benefit of medium textured soil (Jadria) where the highest values for dry weight, P concentration in plant, P uptake, and water soluble P were recorded. The fine textured soil (Gaiara) gave the highest values in water soluble Ca, and EC. The effect of texture on NaHCO<sub>3</sub>-P was not significant. Results affirm the possibility of adopting (50TSP+50PR) treatment as alternative for single application of TSP or PR, due to the non-significancy of the differences between 50TSP+50PR treatment and 60TSP +40PR treatment.

Keywords: PR – TSP – Peat – sludge – organic materials – PAPR – soil texture

## المستخلص :

اجريت تجربة اصص لتحديد دور المواد العضوية ( خث النبات والحماة) المضافة مع الصخر الفوسفاتي والتحميض الجزئي للصخر الفوسفاتي ( بخلطه مع أسمدة فوسفاتية ذائبة بالماء مثل TSP بنسب مختلفة ٥٠:٥٠ و ٦٠:٤٠ TSP :PR ) في فاعلية الصخر الفوسفاتي (الوزن الجاف للنبات، إمتصاص P ، الفسفور المستخلص بالبيكاربونات، والفسفور المستخلص بالماء). إستعمل نبات الذرة الصفراء (*Zea mays* L.) صنف ربيع كمحصول إختبار في تربتين الأولى متوسطة النسجة (الجادرية) والثانية ناعمة النسجة (القيارة). درس أيضاً تأثير المعاملات السمادية في بعض خصائص التربة مثل الكالسيوم الذائب بالماء والتوصيل الكهربائي واس الهيدروجين. أظهرت النتائج أن المعاملة (60 TSP + 40 PR) كانت متفوقة في الوزن الجاف للذرة الصفراء والفسفور المستخلص بالبيكاربونات تلتها المعاملة (50 TSP + 50 PR) بدون فروق معنوية . تفوقت معاملة الصخر الفوسفاتي PR في تركيز P في النبات وإمتصاص P تلتها المعاملة PR + sludge بدون فروق معنوية. أعطت المعاملة (50 TSP +

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PR) أعلى القيم للفسفور الذائب بالماء وأقل القيم للكالسيوم الذائب بالماء و EC و pH. كان التأثير الرئيسي للنسجة لصالح التربة المتوسطة النسجة (الجادرية) إذ أعطت أعلى القيم للوزن الجاف للنبات وتركيز P في النبات وإمتصاص P و الفسفور الذائب بالماء ، فيما أعطت التربة الناعمة النسجة ( القيارة) أقل القيم للكالسيوم الذائب بالماء و EC . كان تأثير النسجة في P المستخلص بالبيكاربونات غير معنوي . أكدت النتائج إمكانية إعتداد المعاملة (50 TSP + 50 PR) كبديل عن الإضافة المنفردة لكل من TSP أو PR لعدم وجود فروق معنوية بينها وبين المعاملة (60 TSP + 40 PR).

## **Introduction:**

The role of phosphorus (P) in increasing yield and improving crops quality is well known. However, low recovery (10- 30%) of phosphorus from applied fertilizers have further complicated the problem of its use by the farmers [1]. It is in this context that there is a need to have a comprehensive approach for P application for sustainable crop production and good P use efficiency. The cost of traditional phosphatic fertilizers like TSP have gone up considerably so it has become necessary to pay attention on the utilization of some low cost native sources of phosphorus such as phosphate rock (PR)[2].

Phosphate rock, which is a slow release phosphate fertilizer, is cheaper than triple super phosphate and has a larger residual effect [3]. The quality factors for direct application of PR are different. Indeed, PR sources suitable for direct application are considered to be "problem ores" because of their low grade and the presence of accessory minerals and impurities [2]. According to the 1975 FAO Annual Fertilizer Review, direct application of PR accounted for only 5 % of total consumption of 10.5 million metric tons of P in 1974-1975 and most of it was used in the developing countries [4]. However, if the characteristics of PR and soil are favorable for direct application, then it would be necessary to increase the effectiveness of PR [5]. Various methods have been explored world over in order to increase the suitability and availability of low phosphate includes: composting with farm manures, green manuring, partial acidulation of PR along with many chemicals..etc [6]. Mattingly [7] found that organic matter usually increase both the concentration of phosphorus in the soil solution and the rate and extent of movement. Results of El-Dewiny et al., [8] showed that the addition of organic matter markedly increased both fresh and dry weight of radish and spinach plants at different stages of plant growth and improved the chemical properties of super phosphate and phosphate rock. Samaras et al., [9] found that sewage sludge application increased soil organic matter associated nutrients (P and N) and improved physical properties. They also found that cotton responded to sludge application by increased nutrient uptake and yield and this was due to the increase in Olsen P and available N. Green house and field experiments were conducted by Waigwa et al., [10] to evaluate the effects of combining different farm organic materials with the PR on available P to maize (corn). They found that PR combined with farm yard manure (FYM) or crop residues (maize Stover) generally increased Olsen P, yield and P uptake particularly in the first season. They concluded that combining PR with organic matter improved its relative agronomic effectiveness for maize. Zapata and Zaharah [11] used PR, sewage sludge, and TSP which were applied alone and combined together at two rates 50, 150 mg P.kg<sup>-1</sup> soil, and found that for a given P rate, P uptake from PR and sewage sludge in presence of TSP was higher than P uptake from these sources alone, indicating an enhancement effect of TSP on effectiveness of these non-readily available sources. The effect of organic residues (chicken manure, farmyard manure, and sugar bagasse) combined with PR on extractable P and benefits, was studied by Kifuko et al., [12]. They found that available P increased linearly with PR rates, and increased in all the

treatments where PR and organic matter were applied separately or combined. Direct application of PR materials to soil as ground mineral phosphate, though can be advocated, is not advisable, as the reactivity is very low [13]. Khasawneh & Doll [14] mentioned that the agronomic effectiveness of PR is higher on acid soil than on neutral or alkaline soils, and that soil acidity has been considered the single most important agent responsible for enhanced availability of PR in PR materials. Terman et al., [15] found that acidulating PR in the soil with H-resin or H<sub>2</sub>SO<sub>4</sub> was considerably less effective for solubilizing PR than acidulation prior to application. Much efforts has been made over the years to establish methods to improve the solubility and agronomic effectiveness of natural sources of PR, such as partial acidulation of PR (PAPR), combining PR with water soluble P fertilizers (TSP or SSP), PR and sulphur assemblages [2],[14],[16]. Partially acidulated phosphate rock (PAPR) is made by only adding a portion of the sulphuric or phosphoric acid required to make single (ordinary) super phosphate or TSP [17]. PAPR of 10-20 % partial acidulation was equal to 100% acidulated PR for corn seedling and alfalfa in growth chamber experiments [14]. Although, it is generally believed that on calcareous soils only water soluble phosphate fertilizers are effective sources of P to plants, there is some evidence that PAPR or granulated mixtures of PR and super phosphate (SP) may be as good a source of P as water soluble P fertilizers in calcareous soils [18]. Bolland et al., [17] measured PAPR effectiveness using (i) yield of dried tops (ii) P content in plant (iii) bicarbonate –extractable soil P (soil test value). Menon & Chien [19] confirmed that, for some PRs (that have low reactivity and high Fe<sub>2</sub>O<sub>3</sub> + Al<sub>2</sub>O<sub>3</sub> contents) compaction (mixing with TSP then compacted into pellets) with soluble P fertilizers is agronomically more effective than partial acidulation. The objectives of this research were: (i) to determine the effect of organic materials on PR agronomic effectiveness (dry weight + P uptake + soil available P) and some soil properties (ii) to determine the effect of PR –TSP combinations on PR agronomic effectiveness and some soil properties, and (iii) to study the effect of soil texture on effectiveness of different fertilizer treatments.

### **Materials & Methods:**

The study consisted of two experiments. This experiment (part 1) represents the first where corn was cropped to study the direct effects. The experiment was conducted in green house (pots).

#### **Soils**

Two soils differ in texture were used in this study, the first soil was medium textured soil (clay loam) brought from Jadria district, the second was fine textured soil (clay) brought from Ninewa Governorate, Gaiara district. Soil samples were taken from 0-30 cm depth, dried, sieved, with a 2 mm sieve. Table 1 indicates some characteristics of the soils used. Analyses of soil samples were carried out according to the standard methods mentioned by Page, 1982 [20].

#### **Fertilizers**

Two sources of phosphate were used, triple super phosphate (TSP), and phosphate rock (PR) which represents concentrated pulverized decalcined phosphate rock and was obtained from phosphate fertilizers plants in Okashat. The rate of application of both sources was 86 kg P. ha<sup>-1</sup> according to the recommendations of Ministry of Agriculture for corn. Analysis of PR is shown in table 2.

**Table 1. Some characteristics of the soils used.**

Property	Unit	Jadria soil	Gaiara soil
EC 1:1	dS.m <sup>-1</sup>	5.46	1.42
pH 1:1	-	7.07	7.43
OM	g.kg <sup>-1</sup>	10.28	14.40
Total N	=	0.91	1.1
Olsen P	mg.kg <sup>-1</sup>	8.1	10.23
Water soluble P	=	0.71	3.62
Water soluble Ca	=	253	93
CaCO <sub>3</sub>	g.kg <sup>-1</sup>	28.75	29.7
Texture		clay loam	Clay
Sand	g.kg <sup>-1</sup>	251	295
Silt	=	400	302
Clay	=	349	403

**Organic materials:**

Two sources of organic materials were used in this study. The first was peat obtained from Soil & Water Resources Center (Ministry of Science & Technology) which represents plant residues subjected to compost process. The second was sludge (sewage sludge) obtained from sewage disposal plant of Baghdad city in Al-Rustamia district. The rate of application of peat and sludge was 2 ton.ha<sup>-1</sup>. Analyses of peat and sludge are shown in table 2.

**Table 2. Analysis of PR, peat and sludge used in the study.**

Analysis	Unit	PR	Peat	Sludge
EC	dS.m-1	-	1.5	4.8
pH	-	-	7.6	6.2
Org. C	g.kg-1	-	420	500
C/N	-	-	20	29.4
N	g.kg-1=	-	21	17
P	=	-	3	2
K	=	-	3.8	4
Ca	=	-	12	29
Mg	=	-	9.5	11
Na	=	-	*	7
P	%	13	-	-
Ca	%	36	-	-
CO <sub>2</sub>	%	2.5	-	-

\*Analysis was not conducted

**Treatments:**

The experiment included six treatments with three replicates for each (6 kg soil.pot<sup>-1</sup>) as follows:

- Trt 1: TSP (1.32 g TSP.pot<sup>-1</sup>)
- Trt 2: PR (1.98 g PR.pot<sup>-1</sup>)
- Trt 3: PR + peat (the same amount of PR as Trt 2 plus 6 g peat)
- Trt 4: PR + sludge (the same amount of PR as Trt 2 plus 6 g sludge)
- Trt 5: 50 TSP + 50 PR ( half the amount of TSP in Trt 1 plus half the amount of PR in Trt 2)
- Trt 6: 60 TSP + 40 PR ( 60% of the amount of TSP in Trt 1 plus 40% of the amount of PR in Trt 2)

**Potting experiment:**

The P fertilizer treatments according to the above six treatments were added to soil samples (6 kg soil for each pot) and mixed thoroughly in plastic bags to incorporate the fertilizers. The

soil was then transferred to the plastic pots. The soils were cropped to corn (*Zea mays* L. var. Rabe) as a test crop. Nitrogen (N) was added at a rate of 320 kg N .ha<sup>-1</sup>, as urea divided on two doses, the first was at planting (0.9 g urea /pot which was dissolved in 100 ml of water) the second was added after the plants reached 20 cm long (1.2 g urea /pot) to all of the pots. The pots were watered then to field capacity with deionized water. Watering was continued daily to field capacity determined by weight. Pots were arranged in randomized complete block design. Seeds were seeded (sawn) at 30/08/2008 and plants were harvested at 15/11/2008. Dry matter yield, P concentration and P uptake were measured (Jackson,1958) [21]. Soil was sampled from harvested pots, and the soil was analyzed for Olsen extractable P, water soluble P, water soluble Ca, EC, and pH according to the standard methods mentioned by Page, 1982 [20].

## **Results & Discussion:**

### **Plant growth:**

Effects of fertilizer treatments on dry weight of corn are presented in Table 3. It was noticed that the addition of different sources of phosphate fertilizers resulted in a different response in plant growth represented by dry weight. Phosphate rock alone caused the least dry weight for both soils. Application of organic materials as peat with PR (Trt 3) caused a significant increase in dry weight for Jadria soil only over PR. Application of organic materials as sludge has no significant effect on dry weight for both soils. Table 3 shows that application of 50%TSP+50%PR (treatment5) had significant increase in dry weight in Jadria soil. Increasing percentage of TSP to 60% gave good results on Gaiara soil only. The effect of texture on utilization of P may be due to the fact that fine textured soils require more P concentration compared with medium textured soils to obtain equal recovery by plants [22]. The main effect of soil texture indicate the superiority of Jadria soil. The main effect of fertilizers shows that TSP gave the highest dry weight (23.83 g/pot) and PR gave the lowest (14.61 g/pot). Partial acidulation of PR by 60% TSP (60 TSP+40PR) or 50% TSP (50TSP+50PR) gave good results. For both soils the ameliorative effect of organic materials was obvious, especially for peat where the increase was significant but it was not so for sludge. The effect of OM on P behavior in soil may be explained by the reduction in adsorption energy of P by adsorption of OM decomposition products on the same sites effective in P adsorption. It was noticed that the dry weight obtained by combination with peat (PR+peat) did not differ significantly than Trt 5 (50TSP+50PR) and Trt 6 (60TSP+40PR) which signify the importance of peat in enhancing PR effectiveness.

**Table 3. Dry weight of corn as affected by fertilizer treatments and soil texture.**

Treatment	Dry weight (g.kg <sup>-1</sup> )		
	Jadria soil	Gaiara soil	Mean*
TSP	25.9	21.8	23.85 A
PR	18.0	11.2	14.60 C
PR + Peat	26.5	13.4	19.95 ABC
PR + Sludge	18.9	12.5	15.70 BC
50 TSP + 50PR	24.0	15.2	19.60 ABC
60 TSP + 40PR	25.9	17.0	21.45 AB
Mean*	23.20 A	15.18 B	

\*Means with the same letter are not significantly different

LSD<sub>0.05</sub> for fertilizers= 5.79

LSD<sub>0.05</sub> for soil = 3.34

Soil X Treatment = not significant

### Nutrient concentration & uptake:

Table 4 revealed that the P concentration in corn plants were influenced by adopted treatments during the growing season. The magnitude of variation of P concentration with respect to organic materials and partial acidulation was very clear. Application of TSP or PR alone did not cause a statistical difference ( $p=0.05$ ) between the two soils. Results showed that application of organic materials caused different response of P concentration in corn plants. Treatment 3 (PR+peat) gave the least P concentration among all the treatments, while Trt 4 gave the higher P concentration among organic treatments and there was no significant differences ( $p=0.05$ ) between Trt 4 and Trt 2 (PR). Partial acidulation of PR with TSP also caused different response of P concentration. Treatment 5 (50TSP+50PR) gave less P concentration than Trt 6 (60TSP+40PR) but the differences were not significant. The lower P concentration by trt 5 and trt 6 compared with the other treatments may be due to the dilution effect. Results also showed that there was no significant difference ( $p=0.05$ ) between the two soils in P concentration. Al-Uqaili (1989)[23] obtained similar results with silty clay and loam soils. Table 5 indicated that TSP treatment induced the highest P uptake by corn plants for the two soils, and it did not differ significantly with other treatments (except Trt3: PR+peat). These results differ than Salomon & Smith (1956) [24] results who found that P uptake due to PR treatment was the highest and TSP treatment was the least in effect. Partial acidulation with the higher ratio of TSP to PR improved P uptake which is in agreement with Mahisarakul et al., (2002)[25]. For Jadria soil TSP was superior in its effect on P uptake and Trt 6 (60TSP+40PR) was the least, and partial acidulation gave lower values than PR or TSP alone. Organic treatments (trt 3 and trt 4) gave less uptake than PR alone. For Gaiara soil TSP treatment was superior in P uptake and Trt 3 (PR+peat) was the least, and application of organic materials reduced P uptake compared with TSP or PR alone. Partial acidulation of PR applied for Gaiara soil improved its effect but the difference was not significant ( $p=0.05$ ). The main effect of fertilizer indicate that Jadria soil (medium textured) gave higher P uptake 23.78 (mg/pot) compared with Gaiara soil (fine textured) 14.66 (mg/pot) and the difference was highly significant ( $p=0.01$ ). This effect of texture may be due to the fact that Jadria soil adsorped less amount of added P compared with Gaiara soil. Interaction between soil and fertilizer treatments was not significant.

**Table 4. Phosphorus concentration in corn plants as affected by fertilizer treatments and soil texture.**

Treatment	P conc. in plant ( $\text{mg.kg}^{-1}$ )		
	Jadria soil	Gaiara soil	Mean*
TSP	1268	838	1053 AB
PR	1377	1283	1330 A
PR + Peat	822	853	838 B
PR + Sludge	1263	1010	1123 A
50 TSP + 50PR	835	1007	921 AB
60 TSP + 40PR	747	942	845 AB
Mean*	1052 A	989 A	

\*Means with the same letter are not significantly different

LSD<sub>0.05</sub> for fertilizers= 515.8

LSD<sub>0.05</sub> for soil = 298

Soil X Treatment = not significant

**Table 5. Phosphorus uptake by corn plants as affected by fertilizer treatments and soil texture.**

Treatment	P uptake (mg. pot <sup>-1</sup> )		
	Jadria soil	Gaiara soil	Mean*
TSP	32.8	18.3	25.6 A
PR	24.8	14.4	19.6 AB
PR + Peat	21.8	11.4	16.6 B
PR + Sludge	23.9	12.6	18.3 AB
50 TSP + 50PR	20.0	15.3	17.6 AB
60 TSP + 40PR	19.4	16.0	17.7 AB
Mean*	23.78 A	14.66 B	

\*Means with the same letter are not significantly different

LSD<sub>0.05</sub> for fertilizers= 7.84

LSD<sub>0.01</sub> for soil = 6.15

Soil X Treatment = not significant

### **Effect on some P fractions:**

Data in table 6 show the status of Olsen extractable P (NaHCO<sub>3</sub>-P) under different fertilizer treatments and texture. In Jadria soil Olsen P in PR treatment was slightly higher than TSP treatment which is compatible with dry weight and P uptake results. Application of organic materials reduce Olsen P compared with PR alone this may be due to the fast transformations of P in the two soils which are calcareous soils to unavailable forms and the formation of organometallic complexes due to the reaction of PR with organic compounds in these amendments (Muhawish, 1995 [26]). Partial acidulation in Jadria soil increase Olsen P and the highest effect was in the sixth treatment (60 TSP + 40 PR) but it was not significantly different with the fifth treatment (50 TSP + 50 PR). Improvement of available P (Olsen P) of soil by partial acidulation suggest that these treatments can support higher corn yields if rates of N and K are increased (table 3) and will reflex on the residual effect of these treatments. These results do not agree with results of Narayana samy & Biswas (2002) [13] who found that P status (Olsen P) due to addition of DAP was markedly higher than those due to partially acidulated PR. In Gaiara soil, nearly the same trend was seen in the P status (Olsen P). The total effect of the fertilizer treatment does not differ significantly (P=0.05) between the two soils, The total effect of soil texture on the behavior of different fertilizers showed that the sixth treatment caused the highest Olsen P then the fifth treatment and they did not differ significantly, followed by TSP and PR alone which were nearly the same, and the least values of Olsen P were in the organic material treatment (treatment 3 & 4). The latter results agree with the finding of Muhawish (1995) [26]. Results also showed that the effect of interaction between soil and fertilizer was not significant.

**Table 6. Olsen extractable P in soil as affected by fertilizer treatments and soil texture.**

Treatment	Olsen P (mg. kg <sup>-1</sup> )		
	Jadria soil	Gaiara soil	Mean*
TSP	10.1	13.6	11.85 B
PR	11.2	11.3	11.25 B
PR + Peat	8.8	5.8	7.30 C
PR + Sludge	5.7	8.6	7.15 C
50 TSP + 50PR	14.3	14.2	14.25 AB
60 TSP + 40PR	17.3	15.0	16.15 A
Mean*	11.24 A	11.42 A	

\*Means with the same letter are not significantly different

LSD<sub>0.01</sub> for fertilizers= 3.8601

LSD<sub>0.05</sub> for soil = 1.6397

Soil X Treatment = not significant

In general, values of water soluble P in soil after cropping (Table 7) were less than the values before cropping. This mean that P applied does not affect this fraction of P in soil, which may be due to rapid transformation of P to insoluble forms in water (Muhawish, 1995)[26] or most of P amounts soluble in water were depleted by plants, and there was not enough time to reach equilibrium state between solid and liquid fractions in soil after harvest. Treatment 5 (50TSP+50PR) induced the highest level of water soluble P which was highly significant ( $p=0.01$ ) in Jadria soil, while TSP treatment induced the lowest level of water soluble P in Gaiara soil. Generally speaking, water soluble P for all of the treatments was significantly higher in Jadria soil compared to Gaiara soil. Treatment 5 gave the highest water soluble P in soil which suggest that water soluble and the water insoluble components of partially acidulated PR interact when PAPR react with soil. The effect of organic materials was clear only in the case of Trt 3 (PR+ peat) in Jadria soil. The interaction effect between soil and fertilizer was significant at  $p=0.01$ .

**Table 7. Water soluble phosphorus in soil as affected by fertilizer treatments and soil texture.**

Treatment	Water soluble P (mg. kg <sup>-1</sup> )		
	Jadria soil	Gaiara soil	Mean*
TSP	0.32	0.15	0.237 C
PR	0.30	0.34	0.317 BC
PR + Peat	0.54	0.35	0.445 AB
PR + Sludge	0.32	0.37	0.345 BC
50 TSP + 50PR	0.81	0.33	0.572 A
60 TSP + 40PR	0.26	0.47	0.363 BC
Mean*	0.426 A	0.334 B	

\*Means with the same letter are not significantly different

LSD<sub>0.01</sub> for fertilizers= 0.1792

LSD<sub>0.05</sub> for soil = 0.0761

Soil X Treatment = Significant ( $p < 0.01$ )

### **Effect on some soil properties:**

In alkaline and calcareous soils  $\text{HPO}_4^{-2}$  ion exists in higher amount compared to  $\text{H}_2\text{PO}_4^{-1}$  for plant, and this due to the existence of Ca and Mg in these soils as calcium or magnesium carbonate the availability of  $\text{H}_2\text{PO}_4^{-1}$  and  $\text{HPO}_4^{-2}$  will be reduced and converted from the ionic form to P compounds varying in their solubilities according to soil type and Ca ion activity, amount and size of  $\text{CaCO}_3$ , and amount and type of clay. Table 8 shows the effect of fertilizer treatments and soil texture on water soluble Ca. Results show that the lowest values enhanced in Gaiara soil (fine textured) which differed significantly ( $p=0.01$ ) than Jadria soil (medium textured). Treatment 5 (50TSP+50PR) and Trt 1 (TSP) caused the lowest values of water soluble Ca in both soils which did not differ significantly. This may be due to the low content of Ca in TSP (12-14%) compared with PR (36%) and the initial content of water soluble Ca in soil and nature of reactions. Interaction between soil and was not significant.

**Table 8. Water soluble Ca in soil as affected by fertilizer treatments and soil texture.**

Treatment	Water soluble Ca (mg. kg <sup>-1</sup> )		
	Jadria soil	Gaiara soil	Mean*
TSP	340	181	261 C
PR	487	628	557 AB
PR + Peat	852	399	626 A
PR + Sludge	506	569	537 AB
50 TSP + 50PR	343	351	347 BC
60 TSP + 40PR	963	532	748 A
Mean*	582 A	443 B	

\*Means with the same letter are not significantly different

LSD<sub>0.01</sub> for fertilizers= 235.01

LSD<sub>0.01</sub> for soil = 135.68

Soil X Treatment = not significant

It is well known that fertilizer salts differ greatly in their effect on the concentration of the soil solution, so that higher analysis fertilizers will generally have a lower salt index per unit of plant nutrients than water soluble, lower analysis fertilizers because they are usually made up of higher analysis materials. For example superphosphate of analysis 20 and 48 will have salt index of 0.39 and 0.21 respectively. In our case analysis of TSP and PR was 19-23% and 11-17% respectively. Table 9 present results of EC values of soil caused by fertilizer treatments and soil texture. It is noticed that Jadria soil showed higher EC values than Gaiara soil (fine) and the differed significantly (P=0.01). For both soils Trt 5 (50 TSP + 50 PR) and Trt 1 TSP enhanced the lowest EC values which did not differ significantly (P=0.01) while the lowest values in Gaiara soil were with Trt 6 and Trt 1. The interaction between soil and fertilizer was not significant.

**Table 9. Electrical conductivity (1:1) of soil as affected by fertilizer treatments and soil texture.**

Treatment	EC (dS.m <sup>-1</sup> )		
	Jadria soil	Gaiara soil	Mean*
TSP	2.75	1.33	2.04 B
PR	3.32	3.74	3.53 A
PR + Peat	3.78	2.54	3.16 AB
PR + Sludge	2.70	2.31	2.67 AB
50 TSP + 50PR	1.78	2.43	2.11 B
60 TSP + 40PR	5.41	1.80	3.60 A
Mean*	3.35 A	2.36 B	

\*Means with the same letter are not significantly different

LSD<sub>0.01</sub> for fertilizers= 1.42

LSD<sub>0.01</sub> for soil =0.82

Soil X Treatment = not significant

Effect of fertilizer treatments and soil texture on soil pH reported in table 10, where it is shown that the main effect of fertilizer and PR (i.e. all treatments) were almost similar and the differences were not significant.

**Table 10. Soil pH (1:1) as affected by fertilizer treatments and soil texture.**

Treatment	Soil pH		
	Jadria soil	Gaiara soil	Mean*
TSP	7.27	7.83	7.55 A
PR	7.67	7.67	7.67 A
PR + Peat	7.37	7.80	7.58 A
PR + Sludge	7.43	7.77	7.60 A
50 TSP + 50PR	7.70	7.50	7.60 A
60 TSP + 40PR	7.83	7.73	7.78 A
Mean*	7.54 A	7.72 A	

\*Means with the same letter are not significantly different

LSD<sub>0.05</sub> for fertilizers= 0.3626

LSD<sub>0.05</sub> for soil = 0.2093

Soil X Treatment = not significant

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