### **Comparing Effects of Treated Rock Phosphate and TSP on Soil P Availability and P Concentration in Apple (***Malus pumila***) Trees**

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Received: 14 December 2009

Accepted: 29 April 2010

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#### ABSTRACT

Phosphorus is one of the major elements in plant nutrition and crop productivity, participating in many biochemical processes and translocation of energy. In addition, P is a constituent of cell nucleic acids. Application of phosphate fertilizers is a common practice to correct P-deficiency in plants. For a long time, rock phosphate (RP) has been a major source to P fertilizer production. For evaluation of the efficiency of combined rock phosphate with different constituents, a garden experiment, as a completely randomized block design, was carried out in Torough Station of Agricultural Center of Khorasan with eleven treatments and three replications. Each replication included two apple trees (there should be 11 treatments or 22 apple trees in each replicate row). Treatments were:  $T_1$ : control (without phosphorous use), T<sub>2</sub>: Using P as triple super phosphate, T<sub>3</sub>: 40% concentrated R P. + 40% S(powdered) + 16% cow manure (CM) + 4\% zinc sulphate,  $T_4$ :  $T_3 + 20$  grams *Thiobacillus* sp. inoculant (10<sup>7</sup> cfu g<sup>-1</sup>), T<sub>5</sub>: T<sub>3</sub> + 40 grams *Thiobacillus* sp. inoculant, T<sub>6</sub>: T<sub>3</sub> + Tea residues instead of CM,  $T_7$ :  $T_4$  + Tea residues instead of CM,  $T_8$ :  $T_5$  + Tea residues instead of CM,  $T_9$ :  $T_3$  + plant residue compost instead of CM, T<sub>10</sub>: T<sub>4</sub> + plant residue compost instead of CM, T<sub>11</sub>: T<sub>5</sub> + plant residue compost instead of CM. In all treatments, 1 kg of each fertilizer was used for each apple tree at a 40 cm depth. Results indicated that there were significant differences among treatments including concentrated RP + S. *Thiobacillus* sp. bacteria and CM, with control treatment and treatments with no Thiobacillus from the aspect of available-P and leaves-P concentrations. Based on the results (P < 0.05) using of RP + S, *Thiobacillus* sp. bacteria + CM at a rate of 1 kg.tree<sup>-1</sup> for each apple tree had the same effect as triple super phosphate.

Keywords: Thiobacillus, Rock phosphate, Apple, Phosphorus

#### INTRODUCTION

Phosphorus is one of the major elements in plant nutrition and crop productivity. This element involves in biochemical many processes and translocation of energy. In addition, P is a constituent of cell nucleic acids. Application of phosphate fertilizers is a common practice to correct P-deficiency in plants. For a long time, Rock phosphate

(RP) has been a major source in P fertilizer production.

Since for the oxidation of S by *Thiobacillus* sp. in the fertilizer, as a biological process, enough time is required, so field crops may not be suitable for this study, therefore a horticultural crop, apple (*Malus pumila*) tree, was selected for this study. Apple tree is one of the most important horticultural crops in Iran. The planting area of apple orchards in Iran is about 158000 hectares (Malakouti,

2000). There are some factors decreasing the amount of apple yield in Iran, including calcareous soils. incorrect irrigation methods and unsuitable quality of irrigation water. Practices such as correction of water, fertilizers management and plant nutrition disorders may increase apple yield and improve the quality of productions (Malakouti, 2000, 2002). The results of researches on the application of RP in acid soils have showed that RP can meet plant demand to P and/or increase the soluble P of phosphate fertilizers. However in calcareous soils of most areas of Iran, RP have low efficiency and addition of may some treatments improve its efficiency. Nourgholipour et al. (2000), and Koochak Zadeh (2001), reported that S, Thiobacillus sp. and R.P. as well as triple super phosphate can increase the uptake of P and yield of corn when the soil TNV haven't been upper 5 percent. Lotfollahi et al. (2000) showed that RP + organic matter, S and Thiobacillus sp. significantly increased corn yield and P uptake. Bakhtiari et al. (2001) reported that RP + S and *Thiobacillus* including Zn as well as triple super phosphate can increase the yield and P uptake of apple trees. Khavazi et al. (2001) showed that RP + Sand Thiobacillus sp. significantly increased the dry yield of corn, in comparison with control, but there were no significant differences between this treatment and triple super phosphate. Since there are high amounts of RP sources and plenty of S in purposed this research to Iran. we investigate the effects of different constituents on the efficiency of RP, and, hence, apple yield.

### MATERIALS AND METHODS

In 2002, a garden experiment, as a completely randomized block design, was carried out in Torough Station of Agricultural Center of Khorasan with eleven treatments and three replications. Each replication included two apple trees. Treatments were: T<sub>1</sub>: control (without any phosphorous), T<sub>2</sub>: using P as triple super phosphate, T<sub>3</sub>: 40% concentrated R P. + 40% S + 16% cow manure (CM) + 4% zinc sulfate,  $T_4$  :  $T_3$  + 20 grams Thiobacillus inoculant ( $10^7$  cfu g<sup>-1</sup>), T<sub>5</sub>: T<sub>3</sub> + 40 grams *Thiobacillus* inoculant,  $T_6$ :  $T_3$ + Tea residues instead of CM,  $T_7$ :  $T_4$  + Tea residues instead of CM, T<sub>8</sub>: T<sub>5</sub> + Tea residues instead of CM,  $T_9$ :  $T_3$  + composted plant residues instead of CM,  $T_{10}$ :  $T_4$  + composted plant residues instead of CM,  $T_{11}$ :  $T_5$  + composted plant residues instead of CM. In all treatments mentioned, 1kg of each fertilizer was used for each apple tree at a 40-cm depth, in deep placement method. Irrigation, performed once in every 10 days. Soil chemical characteristics for the depths of 0 to 30 and 30 to 60 cm are presented in Table 1. Also some of the chemical characteristics of the applied RP are presented in Table 3.

Plant element requirements (except P) for determination of fertilizers application was carried out based on the results of leaf analysis. Nine months after applying the treatments, pH and concentration of available P in pits, concentration of leaves P, Zn in pits and Zn in leaves were measured. Data analysis and diagram plotting were performed using SAS (9.1) and excel statistical software, respectively.

### Effect of different treatments on pit pH

Effects of different treatments on pit pH nine months after treatments application are presented in Figure 1. Among different treatments, control and super phosphate treatments resulted in the highest pit pH values. However, there were no significant effects (P < 0.05) among the treatments. Application of treatments including S and organic matter decreased pit pH. This is attributed to the production of organic acids, CO2 and sulfuric acid due to the

microbial decomposition of organic matter and S oxidation by native microorganisms, respectively. Decomposition of organic matter and CO2 production, in treatments including *Thiobacillus* sp. inoculant (T4, T5, T7, T8, T10, T11) may be higher, compared with other treatments. It seems that the high reduction of pH in these treatments is due to the application of *Thiobacillus* sp. inoculant as S oxidizing bacteria. Producing sulfuric acid. Higher reduction of pH due to simultaneous use of *Thiobacillus* sp. and S has also been reported by other researchers (Mc Cready and Krouse, 1982).

#### **RESULTS AND DISCUSSION**

According to Table 1 the available P concentration is less than the critical level for apple trees. The leaves analysis of apple trees before applying the treatments is presented in Table 2. Accordingly, the concentration of P is lower than the optimum level. In comparison with the external sources of RP the concentration of Cd in applied RP was low.

mg/kg							pН	EC	Depth		
Mn	Cu	Zn	Fe	K	Р	Total N	O.C	T. N. V.		dS/m	(cm)
12.5	0.9	1.6	13.9	270	5.4	0.62	0.98	12.8	8.1	1.2	0-30
15.6	0.8	1.0	8.2	210	4.3	0.49	0.85	9.2	8.1	1	30-60

			11		11.2		,	
		mg/kg				%		
В	Cu	Zn	Mn	Fe	K	Р	Ν	
18	20	23	77	157	1	0.11	1.4	
	Tabl	le 3. Charac	eteristics of th	e applied	l rock phosj	ohate		
	mg/kg		%			EC	pН	
Total Cd	Zn	Fe	P <sub>2</sub> O <sub>5</sub> Tota	1 P <sub>2</sub> O <sub>5</sub>	Soluble	(dS/m)	(1:1)	
2	0.04	2.8	37.5		0.15	0.2	8.9	

Table 2.	Mean	nutrient	contents	of app	le leaves	before	applying	treatments	(n=	3)
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Figure 1. Effects of different treatments on pit pH

#### Effect of different treatments on available P

Available P concentration in pits, nine months after application, is presented in significant Figure 2. There were differences among control and other treatments. There were no significant differences (P < 0.05) between T<sub>2</sub> and T4, T5, T7, T8, T10, and T11 treatments. In these treatments the produced sulfuric acid reacts with dissoluble calcium phosphate, producing the available form of P. This has been reported by many researchers (Stevenson and Col, 1999; Malakouti et al., 2001; Khavazi et al., 2001). In treatments  $T_3$ ,  $T_6$  and  $T_9$  due to the lack of Thiobacillus sp., lower rates of pH reduction and P release occurred. This may show the importance of Thiobacillus sp. as a necessary part of the fertilizer. Figure 4 shows the reverse relation between pH and the concentration of available P in pits. The effects of different treatments on P concentration of apple tree leaves are presented in Figure 3. Control had the lowest concentration of P (0.12%), significantly different (P < 0.05) from other treatments. Treatments T<sub>3</sub>, T<sub>6</sub>, T<sub>9</sub> were significantly different (P < 0.05) from control. In these treatments P concentration increased at a lower rate, compared with T<sub>2</sub> (triple super phosphate). Treatments T<sub>4</sub>, T<sub>5</sub>,  $T_7$ ,  $T_8$ ,  $T_{10}$ , and  $T_{11}$  were not significantly different from T2. These results are in agreement with those, reported by Deluca

*et al.* (1989), Malakouti *et al.* (2001) and Khavazi *et al.* (2001).

## Effect of different treatments on Zn concentration

The effect of different treatments on the Zn concentration of apple leaves, are presented in Figure 4. Treatments T8 and T9 resulted in the lowest and highest Zn concentration of apple leaves, respectively. According to Figure 5 there is a negative relationship between soil available P and leaves Zn concentration. This result is in agreement with those reported by Dawood et al. (1985), Malakouti and Nafisi (1994) confirming the antagonism relationship between P and Zn. This negative effect may be attributed to the transportation of P and Zn from the roots to the upper parts of plant. After P and Zn uptake by plant, they react in the roots and produce organic compounds with low solubility, inhibiting the transport of Zn to the upper part of plant (Tandon, 1992). Also high amounts of P in soil may interfere with some metabolic tasks of Zn in plant, making the transporters of Zn in plant inactive (Dawood et al., 1985).



Figure 2. Effect of different treatments on available phosphorus in pits



Figure 3. Relationship between P and Zn concentration in apple leaves



Figure 4. Effects of different treatments on leaves Zn concentration



Figure 5.Effect of different levels of Thiobacillus sp. inoculant, on the concentration of pit available P

## Effect of different levels of Thiobacillus sp. inoculant on pit pH

Effect of different levels of Thiobacillus sp. inoculant on pH of pits is presented in Figure 6. In this Fig. Ti<sub>0</sub>, Ti<sub>1</sub> and Ti<sub>2</sub> are related to 0, 20 and 40 grams Thiobacillus inoculant /kg (related to the materials and methods section). According to this graph application of 20 and 40 gr Thiobacillus inoculant significantly (P<0.05) sp. reduced the pH of pits (pH changing from 7.13 in  $Ti_0$  to 6.46 in  $Ti_1$  and  $Ti_2$ treatments). There was no significant difference (P < 0.05) between Ti<sub>1</sub> and Ti<sub>2</sub>. In these two treatments with increase in the population of Thiobacillus sp. bacteria S, the rate of S oxidation remained constant. It seems that, according to the ecological requirements of these bacteria and the interaction among the different microorganisms in soil, the population of Thiobacillus bacteria has stayed in a constant level and hence, their population did not increase with increased number of Thiobacillus sp. inoculant. Effect of different number of Thiobacillus sp. inoculant on the concentration of available P in pits is presented in Fig. 5. In this graph, similar to Figure 6 Ti<sub>0</sub>, Ti<sub>1</sub> and Ti<sub>2</sub> are related to 0, 20 and 40 grams Thiobacillus inoculant sp. /kg, respectively. Application of 20 and 40 gr

*Thiobacillus* sp. reduced the pH of pits, and in turn increased the concentration of soil available P, due to increasing P solubility with reducing pH. There were significant differences among  $Ti_0$ ,  $Ti_1$  and  $Ti_2$ , but not between  $Ti_1$  and  $Ti_2$ .



Figure 6. Effects of different levels of *Thiobacillus* sp. inoculant, on pit pH

# Effect of organic matter types on pH and P availability

Effects of organic matter types on reducing pits pH are presented in Figure 7. There was significant differences (P < 0.05) between treatments tea residues, compost and CM, but not between compost and CM treatments. These treatments significantly reduced the pH of pits (pH changing from 6.71 in tea residues treatment to 6.51 in compost and CM treatments). It seems that this is due to the low pH of tea residues

(values, between 3- 4) in comparison to compost and CM.

Effect of organic matter types on the concentration of available P in pits, are presented in Figure 8. There were no significant differences (P < 0.05) between compost and CM treatments, but application of tea residues instead of CM and compost, resulted in significant increase in the concentration of available P in pits.

#### CONCLUSION

Application of compost instead of CM didn't have any significant effect on available P concentration, but application of tea residues significantly increased the concentration of available P in pits. Thiobacillus sp. inoculant was significantly effective. But there was no significant difference between its different levels. It seems that use of 500 gr Thiobacillus sp. inoculant per 25 kg is economical and effective. Based on the results it seems that, 40% concentrated R P. + 40% S + 16% cow manure (CM) + 4% zinc sulfate + 20 grams *Thiobacillus* inoculant  $(10^7 \text{ cfu})$ g<sup>-1</sup>), can be used at a rate of 1 kg/tree in apple orchards, instead of triple super phosphate fertilizer. The efficiency of this fertilizer should be investigated in different areas and also for different crops.



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