

INFLUENCE OF *ASPERGILLUS NIGER* PHOSPHO-COMPOST ON GROWTH, DRY MATTER YIELD AND P UPTAKE OF MAIZE

ABSTRACT

Aims: Soils in Ghana's coastal savanna are typically poor in phosphorus (P), which has an impact on crop growth and productivity. The majority of West African phosphate rock formations are not reactive; therefore, their direct applications do not facilitate easy P availability to crops. Co-composting organic waste with phosphate rock and using phosphorus-solubilizing microorganisms is the new paradigm adopted by scientists in response to the lack of P availability (PSMs). The goals of this study were to (1) assess the effect of *Aspergillus niger* in P dissolution in phosphate rock during composting with citrus waste (CW) and rice straw (RS) and (2) to evaluate the effect of phospho-compost on growth, dry matter yield and P uptake of maize.

Methodology: Preparation of compost took place at University of Ghana Forest and Horticulture Research Center, Okumaning Camp close to Kade. Citrus waste and rice straw were used as feed stock. Each composting pile contained a mixture of urea, Togo phosphate rock, and feedstock in a 1:3:24 weight-to-weight ratio.

Results: According to the findings, citrus waste feedstock was superior to rice straw in dissolving the P in rock phosphate. In a pot experiment, the phospho-composts were assessed using maize (*Zea mays*) as the test crop.

Keywords: *compost, dissolution, greenhouse, microbiological culture*

1. INTRODUCTION

Due to high incidence of Al^{3+} and Fe^{3+} in acidic soils and Ca^{2+} in calcareous soils, African soils are deficient in total phosphorus (0.02 to 0.5 percent) (w/w), of which only 0.1 percent is readily available to plants, a small portion (1 percent) is utilized by plants, and the remaining 99 percent is quickly converted into insoluble complexes (Khan et al., 2009). About 80% of the additional phosphorus fertilizer precipitates as a result of these metal ions complexes. Therefore, in such soils, the phosphorus recovery efficiency is not greater than 20% of the phosphorus applied (Qureshi et al., 2012). In order to increase productivity, substantial increase in synthetic fertilizers usage is required. However, inadequate supply, and altered chemical qualities among other factors limit their continued use. More than 300 billion tons of phosphate rock are available worldwide (Sayma and Shaeba 2019). The fluorapatite rock phosphate in Togo has a significant reserve of P content (27 percent P). Compared to other rock phosphates, it is more accessible in Ghana due to their location. In addition, Togo Rock Phosphate is noted for being inert, which prevents it from dissolving completely to boost crop production. To increase its P release, it needs to be treated (Ghosal and Chakraborty, 2012; Tchangbedji et al., 2003; Agyin-Birikorang et al., 2007). Composting is a successful method for re-using organic waste at a temperature that is controlled for crop production and increasing soil quality (Khan and sharif, 2012). Compost as an amendment enhances the soil's structure, ability to retain water, aeration, and balance of its acidic and basic conditions (Vitousek et al. 2010, Sundara, 2002; Sanders et al., 2002). P solubilization may be aided by increased microbial activity and the acidic conditions produced during the composting process. It has been demonstrated that the application of rock phosphate in soils with very low pH increases phosphorus release (Uwumarongie-illori et al., 2012). According to Malviya et al. (2011), a wide variety of soil fungi have been found to solubilize insoluble phosphates, and strains of *Aspergillus niger* are among those fungi capable of phosphate solubilization. Fungi are significant components of soil microbiota, typically making up more of the soil biomass than bacteria (Goenadi et al. 2000; Abd-Alla and Omar 2001). It is

thought that these microbes can provide phosphate to plants in a way that is more sustainable and beneficial to the environment (Hedayati et al., 2007). They can do this, in particular, by making more phosphorus available in rock phosphate-fertilized soils and by enhancing the physiochemical, biochemical, and biological characteristics of the soil (Malviya et al., 2011). It is in this regard that the ability of *Aspergillus niger* to dissolve P in phosphate rock during composting would be investigated, as well as the impact of phosphor-compost on maize growth, dry matter production, and P uptake.

2. METHODOLOGY

2.1 Research Design

Aspergillus niger was cultured in the Pathology Laboratory of the School of Agriculture, University of Ghana, Legon's Crop Science department. Compost preparation took place at the University of Ghana Forest and Horticulture Research Centre between November 2013 to January 2014. In order to evaluate the effect of phosphor-compost on growth, dry matter yield and P uptake of maize, a pot experiment was carried out in a greenhouse from March to April 2014.

2.2 Culturing of *Aspergillus niger* (Fungi)

The Plant Pathology Laboratory of the Department of Crop Science, University of Ghana, Legon, provided a plate of *Aspergillus niger* spores.

2.3 Preparation of Potato Dextrose Agar (PDA)

Irish potatoes that had been peeled and chopped into 12-millimeter cubes had been weighed into a beaker and given repeated rinses with distilled water. 1.0 L of distilled water was poured to a beaker containing the washed potato cubes, and the beaker was then allowed to boil for one hour. The potato cubes were slightly squeezed through a silent towel. After being poured into a one-liter conical flask, the liquid was filled to the mark with distilled water. Agar and dextrose weighing 20 grams were added, mixed, and heated until dissolved. After sterilizing the mixture for an hour at 15 psi, it was allowed to cool and then stored.

2.4 Data Analysis

Statistix 9 was used to analyze the generated data. One-way analysis of variance was performed on the data (ANOVA). To differentiate the treatment groups, Fisher's Least Square Difference (LSD) was applied at 0.05 ($p < 0.05$) level of probability.

3. RESULTS

3.1 Characterization of feed stock

Some physico-chemical properties of the feed stocks used are presented in Table 1. Citrus trash, which is primarily made up of peel and pulp, contains digestible crude fiber and protein as well as soluble and insoluble carbohydrates. Citrus waste feedstock had a C/N ratio of 27.8, which is within the range that is ideal for composting (Verdonck, 1988), while rice straw feedstock had a C/N ratio of 48.1, which was then reduced by 32.4 by adding a N source (Urea). Similar to those found by Kumari et al., rice straw has similar C and N concentrations (2008). Van Heerden et al. (1995) reported that the C: N ratio for citrus trash was 28:1.

Table 1: Chemical composition of the feedstock.

Material	Total P	Total N	Organic C	C:N
Citrus waste	0.18	0.99	47.5	48.1
Rice straw	0.23	1.48	41.2	27.8

3.2 Initial Study Findings

The findings of a preliminary investigation on whether to apply sterilizing agents prior to inoculating piles with *Aspergillus niger* are shown in Table 2. The investigation compared two substrates, citrus waste and

rice straw. There was no significant difference in the amount of accessible P between the citrus waste (CW) compost with and without NaOHCl. The rice straw feedstock had a similar outcome.

Table 2: Effect of NaOHCl on treatment as a sterilizing agent in week 2.

Treatments	pH	Available P (%)
CW, RP, U, <i>A. niger</i>	3.5	0.64
CW,RP,U, <i>A. niger</i> , NaOHCl	3.6	0.61
RS, RP, U, <i>A. niger</i>	6.5	0.47
RS, RP, U, <i>A. niger</i> , NaOHCl	6.8	0.50
P-value	0.00	0.00
LSD	0.25	0.05
CV (%)	2.57	5.10

3.3 P uptake of shoot

While Control had the lowest P uptake (0.5 t/ha), Citrus waste (CW) phosphor-compost without *Aspergillus niger* at 120 kg P/ha and Citrus waste with *Aspergillus niger* at 60 kg P/ha recorded the highest P uptake (3.7 t/ha). For P uptake in shoots, Citrus waste phospho-compost with *Aspergillus niger* at 120 kg P/ha recorded 2.7 t/ha and was followed closely by Citrus waste phospho-compost with *Aspergillus niger* at 180 kg P/ha (2.6 t/ha). Citrus waste phosphor-compost without *Aspergillus niger* observed higher P uptake at 60-kilogram P/ha (3.1 t/ha) than at 180 kg P/ha (2.3 t/ha). The highest P uptake for rice straw phosphor-compost without *Aspergillus niger* was measured at 120 kg P/ha (3.3 t/ha), followed by 180 kg P/ha (2.8 t/ha), and finally 60 kg P/ha (1.8 t/ha). Similar results were obtained with rice straw *Aspergillus niger* phosphor-compost at 120 kg P/ha (3.1 t/ha), 180 kg P/ha (3.9 t/ha), and 60 kg P/ha (1.9 t/ha). The shoot P uptake in the control and rock phosphate with *Aspergillus niger* was the same (0.5 t/ha), and that of triple super phosphate was 1.5 t/ha. Generally, P uptake in shoot was in the order of Citrus waste with *Aspergillus niger* = citrus waste without *Aspergillus niger* > rice straw with *Aspergillus niger* = rice straw without *Aspergillus niger* = triple super phosphate > rock phosphate with *Aspergillus niger* = Control was the order of the shoot P uptake (Table 3).

3.4 Dry Matter Yield of shoot

Results revealed that *Aspergillus niger* inoculation had no impact on the effect of phosphorus source on dry matter yield (DMY) but rather dependent on the kind of feed stock and rate of administration. The highest dry matter yield of 374 (t/ha) was observed among these treatments; citrus waste phosphor-compost without *Aspergillus niger* (60 kg P/ha and 120 kg P/ha) and citrus waste phosphor-compost with *Aspergillus niger* (60 kg P/ha). The lowest dry matter yield of 107 (t/ha) was recorded in the control treatment. Dry matter yield decreased with increase application rates of citrus waste phosphor-compost whereas that of rice straw phosphor-compost saw an increase in dry matter yield as the application rates increases (Table 3).

Table 3: Effect of compost type and application rate on P uptake and dry matter yield of maize shoot at week 7.

Material	P uptake (t/ha)	Shoot DMY (t/ha)
CW, RP, U at 60kg P/ha	3.1	374
CW, RP, U at 120kg P/ha	3.7	374
CW, RP, U at 180kg P/ha	2.3	267
CW, RP, U, <i>A. niger</i> at 60kg P/ha	3.7	374
CW, RP, U, <i>A.niger</i> at 120kg P/ha	2.7	267
CW, RP, U, <i>A.niger</i> at 180kg P/ha	2.6	294
RS, RP, U at 60kg P/ha	1.8	294
RS, RP, U at120kg P/ha	3.3	320
RS, RP, U at 180kg P/ha	2.8	267
RS, RP, U, <i>A. niger</i> at 60kg P/ha	1.9	240
RS, RP, U, <i>A. niger</i> at 120kg P/ha	3.1	294
RS, RP, U, <i>A. niger</i> at 180kg P/ha	2.9	320
TSP	1.8	214
RP, <i>A. niger</i>	2.1	120
Control	0.5	107
P-value	0.00	0.00
LSD	0.15	1.43
CV (%)	3.58	0.31

4. DISCUSSION

The findings showed that both citrus waste and rice straw compost piles, with or without the inclusion of *Aspergillus niger*, consistently experienced a drop in temperature from Day 20 to Day 90. Compost piles treated with *Aspergillus niger* generally had greater temperatures than untreated piles. On Day 90,

temperatures in the compost piles in every case stabilized between 21°C to 29°C. Microbial activity may be the cause of a rise in temperature. Citrus waste-inoculated compost observed a quick rise in temperature from 39.4°C to 57.6°C during the 2nd week of composting, indicating enhanced microbial activity in the compost pile. The pH of the rice straw compost, which was high during the first week of composting, decreased over the following three weeks, from 7.5 to 5.2 for RS without *Aspergillus niger* to 7.1 to 4.1 for RS with *Aspergillus niger*. By the end of the sixth week, the pH of all compost piles were between 7.1 and 7.4. Similar findings were reported by Motaal et al. (2005), who noted that fermentation was responsible for the pH drop during the first few days of decomposition. According to De Bertoldi et al. (1983) the ideal pH range for mature compost was between 5.5 and 8.0. The observed variations in P dissolution between the citrus waste and rice straw composting appeared to be more feedstock-based than *Aspergillus niger* inoculation-based. The findings of this study support other studies (Adu, 2006) that the type of organic material or feedstock utilized in the composting process affects the solubility of P from rock phosphate. The chemical and physical characteristics of organic materials vary widely, and these characteristics may have an impact on the composting process and the subsequent release of breakdown products.

5. CONCLUSION

The investigation has supported the preliminary findings that direct application of Togo rock phosphate (TPR) inhibit the release of P for plant uptake. Direct application of Togo rock phosphate with *Aspergillus niger* did not boost the solubilization of P from the rock phosphate since the combination only increased dry matter yield and P absorption to levels equivalent to the control. P in the rock phosphate could be effectively dissolved using citrus waste and rice straw since they performed better than both TPR with *Aspergillus niger* and the control. However, the amount of P that could be dissolved in the rock phosphate after *Aspergillus niger* inoculation of the feedstock was not particularly high. Nonetheless, Citrus waste phospho-compost performed better at advancing maize growth in soil than rice straw phospho-compost. A positive correlation was observed between P uptake and dry matter yield of maize thus as P uptake increases, shoot dry matter yield also increased.

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