ROLE OF *ASPERGILLUS NIGER* IN SOLUBILIZING P IN TOGO ROCK PHOSPHATE DURING COMPOSTING WITH DIFFERENT ORGANIC WASTES

ABSTRACT

The immobilization and mineralization processes carried out by soil microorganisms have a significant role in controlling the availability of phosphorus in soil. A class of helpful microorganisms known as phosphate solubilizing microbes (PSMs) are able to hydrolyze insoluble organic and insoluble inorganic phosphorus compounds into soluble P form that is readily taken by plants. The objective of this study was to evaluate the role of different organic waste and *Aspergillus niger* in solubilizing P in Togo rock phosphate during composting. Composts were prepared using rice straw and citrus waste that had been inoculated with *Aspergillus niger* and supplemented with rock phosphate. The results showed that citrus waste feedstock was more effective than rice straw in solubilizing the P in rock phosphate.

Keywords: Spore, Soil pH, Phosphor-compost, Solubilization, Inoculation, Phosphorus solubilizing fungi (PSF).

1. INTRODUCTION

As a primary raw material for making chemical phosphatic fertilizers, rock phosphate is mainly tricalcium phosphate with minimal plant-available P [1, 2]. The rate at which P in the apatite is released under suitable chemical conditions varies depending on the origin, crystallography and physicochemical properties of the rock phosphate. Deposits of igneous and sedimentary origin are less reactive because of their crystalline structure while rock phosphate of sedimentary origin with microcrystalline structure turn to be very reactive [3, 4]. As a result, direct application of rock phosphate with low/medium in reactivity is not economically feasible, particularly in soil conditions characterized by a high P sorption capacity, low cation exchange capacity, high pH, low rainfall, low organic matter content, and low microbial activity [5, 6, 7]. In order to enhance the agronomic efficiency of rock phosphate, [8] proposed partial acidulation that is reacting rock phosphates, usually with H_2SO_4 or H_3PO_4, in amounts less than that needed to make SSP or triple superphosphate as a method for effectively releasing P from rock phosphates. According to [9], and [10], adding partially acidulated phosphate rock (PAPR) to a soil with a pH of 6.5–8.0 had the same impact as adding superphosphate. However, most soil management strategies are mainly dependent on inorganic chemical-based fertilizers, which caused a serious threat to human health and environment. Composting organic wastes with PR is an environmentally friendly technique to increase the agronomic performance of PRs used as phosphate fertilizers [11]. During the composting process, microorganisms aid in the decomposition of the organic material. According to [12] organic acids (such as oxalic, citric, tartaric, and gluconic) are secreted as a result of microbial breakdown of organic matter which reduces the pH or by complexing cation that is bound to phosphorous, have a favorable effect on the dissolution of rock phosphate. By solubilizing and mineralizing complex phosphorus compounds, soil microorganisms have been found to be generally effective at making phosphorus available to plants from organic and inorganic sources [13, 14]. In particular, both applied and native phosphorus solubilizing fungi (PSF) are reported to play a significant role in increasing the phosphorus efficiency by improving the growth and yield of various crops [15]. *Aspergillus niger* is a common soil fungus known for its capacity to produce organic acids, particularly the commercial production of citric acid [16, 17, 18 & 19]. *Aspergillus niger* is notorious for its black sporulation and widespread distribution, making it a significant contaminant in lab cultures. Tri-carboxylic acid also known as citric acid has been shown to be more effective than other organic acids for complexing calcium and dissolving PR. It also functions as a potent chelator [20]. It is against this background that the present study sought to assess the solubilization potential of *Aspergillus niger* in phosphocompost preparation along with low grade rock phosphate using citrus waste and rice straw feedstock.

2. MATERIALS AND METHODS

2.1 Collection of feed stocks

Citrus waste and rice straw were collected from University of Ghana Forest and Horticulture Research Center Farm at Kade and Soil and Irrigation Research Center of the University of Ghana at Kpong respectively. Feed stocks were chopped into smaller pieces.

2.2 Rock phosphate source

Togo rock phosphate (TPR) used was obtained from WIENCO, Accra.

2.3 Fungi source

Aspergillus niger spores was obtained from the Plant Pathology Laboratory of the Department of Crop Science, University of Ghana, Legon.

2.4 Compost preparation

Compost piles comprised of twenty-four kilograms (24 kg) of feed stocks, 3kg (12.5%) of rock phosphate, 1kg (4%) of urea to regulate the C:N ratio and *Aspergillus niger* where necessary. This is in line with the suggestion of [21]. Each treatment was replicated three times and maintained at 60% moisture content throughout the composting process. After thorough mixing, feedstocks were transferred into designated containers and kept under controlled environment. In order to achieve regular aeration, the feedstock was turned every other day. With the help of a thermometer, temperature of the piles was monitored daily.

2.5 Statistical analysis

Analysis of variance was carried out on data collected using statistix 9. The significance was then evaluated using the least significant difference (LSD) at 5% level significance.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Compost temperature as influenced by different organic waste

Generally, during the first 10 days of composting, the temperature of the piles spiked sharply but fell over time (Table 1). In comparison to rice straw compost, the temperature of the citrus waste compost pile increased quickly. In the rice straw without *Aspergillus niger*, the temperature increased from 37^{0}C to 42^{0}C and to 51.2^{0}C by day 20, while the temperature in the citrus waste compost pile rose from 39.6^{0}C to 54.1^{0}C from day 5 to day 10. In a compost pile containing *Aspergillus niger*, a similar observation was made. Citrus waste compost inoculated with *Aspergillus niger* reached its highest temperature on day 10 (57.6^{0}C) and recorded a temperature of 39.4^{0}C on day 5, whereas rice straw compost inoculated with *Aspergillus niger* reached temperatures of 37.5^{0}C and 55^{0}C on days 5 and 20, respectively. Temperature of the compost piles consistently declined from day 20 and by 90 temperature range were between 21^{0}C and 29^{0}C in both citrus waste and rice straw compost piles with or without *Aspergillus niger* inoculation.

Table 1: Compost temperature as influenced by different organic waste

Compost materials	Day 5	Day 10	Day 20	Day 30	Day 60	Day 90
CW, RP, U	39.6	54.1	40.2	40.0	29.0	24.5

CW, RP, U, *A. niger*	39.4	57.6	43.6	36.9	32.0	29.1
RS, RP, U	37.0	42.0	51.2	32.5	26.0	23.5
RS, RP, U, *A. niger*	37.5	40.7	55.0	39.0	29.0	21.0
P-value	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
LSD	**0.23**	**0.16**	**0.23**	**0.13**	**0.13**	**0.52**
CV%	**0.32**	**0.18**	**0.26**	**0.24**	**0.24**	**1.13**

3.1.2 Effect of different organic waste on pH during compost production

The pH of the compost for citrus waste decreased from 4.96 to 3.5 in the second week for case of citrus waste without *Aspergillus niger* and from 4.6 to 2.9 in the case of citrus waste with *Aspergillus niger* (Table 2). The acidic pH of citrus waste feedstock supports earlier research by [22]. However, rice straw compost whose pH was high during the first week of composting, decreased over the following three weeks from 7.5 to 5.2 in favour of rice straw without *Aspergillus niger* and 7.1 to 4.1 for rice straw with *Aspergillus niger*. All compost piles were between 7.1 and 7.4 by the end of the sixth week. Similar findings were reported by [23], who noted that fermentation was responsible for the pH drop during the first few days of decomposition. In line with [24] report that the ideal pH range for mature compost was between 5.5-8.0, all compost piles with or without *Aspergillus niger* were within the range of 7.1 - 7.4.

Table 2: Effect of different organic waste on pH during compost production

Compost materials	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**
CW, RP, U	4.9	3.5	4.7	5.6	6.6	7.2
CW, RP, U, *A. niger*	4.6	2.9	4.3	5.1	7.2	7.1
RS, RP, U	7.5	6.0	5.2	5.4	6.5	7.1
RS, RP, U, *A. niger*	7.1	6.5	5.2	4.1	6.4	7.4

P-value	0.0	0.00	0.00	0.00	0.00	0.00
LSD	0.16	0.16	0.16	0.19	0.19	0.19
CV%	1.44	1.83	1.79	1.98	1.50	1.39

3.1.3 Available P dynamics during compost production

The type of feedstock utilized had a substantial impact on the available P content of composts. The available P levels varied over time in all four compost piles. The greatest accessible P during the first week of composting was 0.35% (Citrus waste without *Aspergillus niger*) and the lowest was 0.31% (Rice straw with *Aspergillus niger*), but there were no appreciable variations in available P among the four composts during that time Table 3). In Citrus waste without *Aspergillus niger*, the available P increased from week 1 to week 3 and decreased between weeks 4 and 6.

Table 3: Available P levels in compost as affected by different feedstock and *Aspergillus niger* inoculation

Compost materials	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
CW, RP, U	0.32	0.70	1.09	1.01	0.97	0.93
CW, RP, U, *A. niger*	0.35	0.84	2.10	1.30	1.08	1.06
RS, RP, U	0.32	0.75	0.80	0.82	0.72	0.62
RS, RP, U, *A. niger*	0.31	0.82	0.92	0.92	0.89	0.83
P-value	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
LSD	**0.02**	**0.05**	**0.01**	**0.02**	**0.02**	**0.02**
CV%	**3.08**	**3.34**	**4.13**	**1.21**	**0.95**	**1.16**

3.2 Discussion

The decomposition process during composting generates a measurable amount of heat due to metabolic activities of microorganisms. The mesophilic phase was characterized by metabolic activity of various heterogeneous group of microorganisms resulting in increased temperature to 45^0C within the first few days as these microbes utilizes the N and C of the organic matter for their body assimilation. As the temperature of the piles rises, the mesophilic microorganisms are replaced with thermophilic ones (temperature higher than

55^0C) which is subsequently reduced to about 40^0C during the cooling phase and later to a temperature range between 20^0C to 30^0C. Similar observations were made by [12] in their article Phases and factors responsible for efficient and improved composting. With regard to pH, the initial pH of the composting piles was different for the CW and RS-based feedstock. This was due to the initial chemical properties of the feedstock. However, irrespective of the initial pH of the pile, there was an increase in pH at the maturation phase of the composting process. This could be probably due to the degradation of acid-type compounds, such as carboxylic and phenolic groups, as well as the mineralization of compounds, such as proteins, amino acids and peptides to ammonia. These results are consistent with the report of [25] which showed that phosphate solubilizing organisms are capable of reducing pH of culture medium. Citrus waste feedstock inoculated with *Aspergillus niger* treatment was more effective in solubilizing P in the rock phosphate and this could be attributed to the production of organic acids that may increase solubilization of P resulting in high release of available P. [26] reported that decreasing soil pH increases rock phosphate effectiveness. Similarly, [6, 27] also reported that, the amount of rock phosphate dissolved decrease either exponentially or linearly with an increasing soil pH.

4. Conclusion

Composting is most efficient when the temperature of the composting material is within the two ranges known as Mesophilic (27^0C - 49^0C) and Thermophilic (41^0C- 66^0C). The composting pH depends largely on the type of feedstock. Finally, out of the four composting piles, co-inoculation system with PSF (i.e. *Aspergillus niger*) provided optimum condition for P solubilization.

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