

## Effect of Water Hyacinth (*Eichhornia crassipes*), Mussoorie Phosphate Rock and Pyrite on the Enrichment of Paddy-Straw Compost

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**Abstract** Enriched nitro-phospho-sulphocomposts were prepared from paddy straw and water hyacinth amended with mussoorie phosphate rock (MRP) and pyrite in different combinations. Paddy straw and water hyacinth in 1 : 1 ratio amended with MRP @ 2.5% P<sub>2</sub>O<sub>5</sub> and pyrite in 1 : 1 ratio of MRP : Pyrite produced superior enriched compost (C : N ratio of 13.91, 1.54% total N, 132 ppm NH<sub>4</sub>-N and 514 ppm NO<sub>3</sub>-N, 2.67% total P, 1.93% citrate soluble P, 2.11% available S, 7.89% fulvic acid and 14.11% humic acid) over composts prepared from only paddy straw amended with MRP @ 5% P<sub>2</sub>O<sub>5</sub> and MRP :

Pyrite in 1 : 2. Pyrite in 1 : 1 ratio of MRP : Pyrite not only helped the decomposition but also increased sulfur content as well as solubilization of insoluble phosphate of mussoorie phosphate rock.

**Keywords** Enriched compost, Phosphate solubilization, Phosphate rock, Pyrite, Water hyacinth.

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### Introduction

The annual addition of plant nutrients through fertilizers is always less than its consumption in India and the high yielding varieties of different crops are continuing to exhaust the nutrient reserves of our soils [1]. Composting of our huge organic residues is a viable option to bridge up the nutrient gap as well as improve the sustainability of our production system. The major qualitative bottleneck is the low nutrient contents of the composts. Several researchers have so far studied on improving the quality of composts through enriching its phosphorus as well as nitrogen content [2]. India has enough availability of water hyacinth, an aquatic weed with high content

of nitrogen and phosphorus and its disposal is a great environmental concern. India has also a huge deposit of non-premium (low grade) phosphate rock which is unfit for the production of conventional phosphatic fertilizers [3]. The insoluble phosphate of phosphate rock can be effectively solubilized by the action of decomposing residues during composting [4]. The application of pyrites can also effectively contribute to solubilizing the insoluble phosphate of phosphate rock by its acidic action on oxidation [5].

Keeping these points in consideration, this present study aims at producing an enriched nitro-phospho-sulpho-compost utilizing paddy straw, water hyacinth, mussoorie phosphate rock and pyrites.

### Materials and Methods

Different combinations of organic substrates, viz., paddy straw (organic carbon 49.65% and total nitrogen 0.49%) and water hyacinth (organic carbon 37.6% and total nitrogen 2.46%) were used for composting. A slurry was prepared by mixing fresh cowdung, alluvial soil and well rotten compost on dry weight basis in the ratio of 1.0:0.5:0.5 for each eight part of organic substrate. The slurry, being the natural harbinger of composite decomposing micro-organisms, was uniformly spread over the chopped organic substrates. Low grade mussoorie phosphate rock (total  $P_2O_5$  17.5%, available  $P_2O_5$  0.021%), iron pyrites (22.1% sulfur) and urea were applied over the organic substrates as per the treatment schedule. Compost heaps each with 200 kg of organic substrates were prepared for each treatment which was replicated thrice. The top of the heaps were mulched followed by covering with polythene sheet to conserve heat and moisture. The heap was periodically checked at an interval of 15 days and watered to just moisten the heap whenever required. The materials of the heaps were turned at an interval of 30 days. The materials were allowed to decompose for 3 months.

The treatment schedule was as follows :

- $T_1$  : Paddy Straw (PS) alone (Control),  
 $T_2$  :  $T_1$  + Mussoorie phosphate rock (MRP) @ 2.5%  $P_2O_5$  of organic substrate,

- $T_3$  :  $T_2$  + Pyrites in the ratio of MRP : pyrites :: 1 : 1,  
 $T_4$  :  $T_2$  + Pyrites in the ratio of MRP : Pyrites :: 1 : 2,  
 $T_5$  :  $T_1$  + MRP @ 5.0%  $P_2O_5$  of organic substrate,  
 $T_6$  :  $T_5$  + Pyrites in the ratio of MRP : Pyrites :: 1 : 1,  
 $T_7$  :  $T_5$  + Pyrites in the ratio of MRP : Pyrites :: 1 : 2,  
 $T_8$  : PS + Water Hyacinth (WH) [1 : 1] + MRP @ 2.5 %  $P_2O_5$  + Pyrites @ MRP : Pyrites :: 1 : 1,  
 $T_9$  : PS + WH (1 : 1) + MRP @ 2.5%  $P_2O_5$  + Pyrites @ MRP : Pyrites :: 1 : 2,  
 $T_{10}$  : PS + WH (1 : 1) + MRP @ 5.0%  $P_2O_5$  + Pyrites @ MRP : Pyrites :: 1 : 1,  
 $T_{11}$  : PS + WH (1 : 1) + MR @ 5.0%  $P_2O_5$  + Pyrites @ MRP : Pyrites :: 1 : 1.

Samples were taken from each heap after 3 months of decomposition period after through uniform mixing for the analysis of organic carbon, total N,  $NH_4$ -N and  $NO_3$ -N citrate soluble P and available sulfur and humic acid and fulvic acid [6]. All the data were analyzed statistically.

### Results and Discussion

The data on the following parameters of the matured compost samples are presented in Table 1 and accordingly discussed.

#### Loss in weight

Decomposition of the organic substrates in each heaps caused loss in organic carbon and thereby resulted in loss in weight which ranged from 29.4—69.6%. Least loss in weight was recorded in  $T_1$  having paddy straw alone as organic substrate. The highest loss in weight was recorded in  $T_8$  where paddy straw and water hyacinth in 1 : 1 ratio were treated with MRP 2.5%  $P_2O_5$  and pyrites in the ratio of MRP : Pyrite of 1 : 1. Water hyacinth treated composts recorded greater weight loss that might be ascribed to greater microbial decomposition due to its more nutrient content [2]. Among the paddy straw composts, MRP treated composts recorded greater

**Table 1.** Composition of phospho-nitro-sulpho compost after 3 months of decomposition.

| Treatments          | Weight loss (%) | Organic carbon (%) | Total nitrogen (%) | C : N | NH <sub>4</sub> -N (ppm) | NO <sub>3</sub> -N (ppm) | Total P (%) | Citrate soluble P (ppm) | Available S (%) | Humic acid (%) | Fulvic acid (%) |
|---------------------|-----------------|--------------------|--------------------|-------|--------------------------|--------------------------|-------------|-------------------------|-----------------|----------------|-----------------|
| T <sub>1</sub>      | 29.4            | 37.28              | 0.74               | 50.38 | 41.0                     | 64.0                     | 0.29        | 0.17                    | 0.08            | 6.31           | 2.12            |
| T <sub>2</sub>      | 63.6            | 24.52              | 1.19               | 20.60 | 60.3                     | 341.0                    | 2.21        | 1.68                    | 0.52            | 10.41          | 6.42            |
| T <sub>3</sub>      | 62.4            | 23.91              | 1.15               | 20.79 | 62.1                     | 372.1                    | 2.16        | 1.62                    | 1.72            | 10.42          | 6.92            |
| T <sub>4</sub>      | 51.2            | 30.43              | 0.94               | 32.37 | 54.5                     | 253.2                    | 1.62        | 0.92                    | 1.51            | 8.92           | 5.26            |
| T <sub>5</sub>      | 56.6            | 32.90              | 1.02               | 24.92 | 56.2                     | 285.1                    | 3.52        | 1.62                    | 1.32            | 7.45           | 4.41            |
| T <sub>6</sub>      | 55.1            | 33.20              | 0.97               | 25.34 | 57.3                     | 283.0                    | 3.40        | 1.56                    | 1.29            | 7.61           | 4.45            |
| T <sub>7</sub>      | 48.0            | 36.71              | 0.88               | 31.11 | 51.0                     | 241.4                    | 2.82        | 1.42                    | 1.10            | 6.15           | 3.85            |
| T <sub>8</sub>      | 69.6            | 21.42              | 1.54               | 13.91 | 132.1                    | 514.1                    | 2.67        | 1.93                    | 2.11            | 14.11          | 7.89            |
| T <sub>9</sub>      | 53.2            | 28.41              | 1.40               | 20.01 | 126.2                    | 472.0                    | 2.12        | 1.75                    | 1.67            | 14.10          | 5.42            |
| T <sub>10</sub>     | 52.1            | 27.62              | 1.39               | 19.87 | 112.0                    | 340.0                    | 3.75        | 1.55                    | 1.49            | 7.45           | 4.01            |
| T <sub>11</sub>     | 47.2            | 29.41              | 1.14               | 25.80 | 101.4                    | 302.5                    | 3.50        | 1.39                    | 1.31            | 6.20           | 3.84            |
| CD <sub>(0.5)</sub> | 2.9             | 1.1                | 0.12               | 1.54  | 4.9                      | 31.0                     | 0.17        | 0.15                    | 0.13            | 1.2            | 1.7             |

weight loss due to enhanced decomposition over the non-MRP treated ones. It might be attributed to the favored microbial growth due to greater nutrition from phosphate rock [7]. But the decomposition decreased significantly in MRP @ 5% P<sub>2</sub>O<sub>5</sub> treated composts over MRP @ 2.5% P<sub>2</sub>O<sub>5</sub> treated ones. Application of pyrites in 1 : 1 ratio with MRP, though decreased the decomposition but the decrease was not significant but the decrease in 1 : 2 ratio with MRP was significant. It might be due to the production of acidity in compost heap to the level that retarded the decomposition significantly. Further, the increased activity of Fe<sup>3+</sup> and Ca<sup>2+</sup> due to oxidation of pyrites and dissolution of MRP in the higher doses might have interacted with organic matter forming complexes more resistant to microbial decomposition.

#### Organic carbon

Organic carbon content of composts ranged from 21.42—37.28%. The lowest value was recorded in T<sub>8</sub> where paddy straw and water hyacinth in 1 : 1 ratio were treated with MRP @ 2.5% P<sub>2</sub>O<sub>5</sub> and pyrites in the ratio of MRP : pyrite of 1 : 1. Greater decomposition in water hyacinth treated composts recorded less organic carbon values. The highest organic carbon value was recorded in T<sub>1</sub> compost (control). Keeping parity in the data of weight loss, phosphate rock as well as pyrite in the lower doses recorded less organic values due to greater decomposition.

Water hyacinth contributed to greater decomposition when mixed with paddy straw over only paddy straw composts, thereby registering less value of organic carbon.

#### Total nitrogen

Total nitrogen in different composts vary from 0.74—1.54%, the highest was recorded in T<sub>8</sub> and least in T<sub>1</sub> (control). Highest value of total nitrogen in T<sub>8</sub> might be due to lower dose of phosphate rock as well as pyrites which might have favored microbial decomposition. The higher nitrogen content of water hyacinth mixed paddy straw composts might be due to greater nitrogen content of water hyacinth.

#### C : N ratios

The least C : N ratio value (13.91) was registered in T<sub>8</sub> and highest in control, T<sub>1</sub>. Decrease in organic carbon and increase in total nitrogen content with decomposition caused a concomitant decrease in C : N ratio values of the composts.

#### NH<sub>4</sub>-N and NO<sub>3</sub>-N

In all the compost samples, both NH<sub>4</sub>-N and NO<sub>3</sub>-N increased over T<sub>1</sub> (control). Both the highest values of NH<sub>4</sub>-N (132.0 ppm) and NO<sub>3</sub>-N (514 ppm) were recorded in T<sub>8</sub> and least values of NH<sub>4</sub>-N (41.0 ppm) and NO<sub>3</sub>-N (64 ppm) were recorded in T<sub>1</sub>. The

combination of MRP and pyrites in  $T_8$  treatment favored the microbial growth and thereby increased the mineralization of organic nitrogen. The later stages of composting might have created favorable aerobic situation in compost heaps that probably caused a greater rate of aerobic transformation and thereby resulting in much higher values of  $\text{NO}_3\text{-N}$  than that of  $\text{NH}_4\text{-N}$ .

#### Total P

Total P content varied from 0.29—3.75%, lowest in  $T_1$  (control) and highest (3.75%) in  $T_{10}$  where MRP @ 5.0%  $\text{P}_2\text{O}_5$  and pyrite in the ratio of MRP : Pyrite of 1 : 1 were applied to paddy straw-water hyacinth (1 : 1). The other higher doses of MRP application also recorded higher total P content. The treatment  $T_8$  where paddy straw and water hyacinth in 1 : 1 ratio were treated with MRP @ 2.5%  $\text{P}_2\text{O}_5$  and pyrites in the ratio of MRP : Pyrite of 1 : 1, recorded less total P content (2.67%) because of application of less amount of MRP.

#### Citrate soluble P

The value of citrate soluble P, an index of plant available P, was recorded highest (1.93%) in  $T_8$  and the least 0.17 % in  $T_1$  (control). Though the treatments  $T_5$ — $T_7$  and  $T_{10}$ — $T_{11}$  received MRP in higher level (5 %  $\text{P}_2\text{O}_5$  basis), respective citrate soluble P content did not record higher values as higher level of MRP might have affected microbial decomposition. The data on citrate soluble P suggested that conjunctive application of MRP and pyrite in the ratio of MRP : Pyrite 1 : 1 increased the values of citrate soluble P in the compost samples over the only MRP application. This might be ascribed to greater solubilization of insoluble phosphate of MRP by acidic action of sulfur source [5]. Higher rate of pyrite application in  $T_4$ ,  $T_7$ ,  $T_9$  and  $T_{11}$  retarded the microbial decomposition of compostable substrate as evident from the data of loss in weight which might be the reason for less value of citrate soluble P.

#### Available sulfur

Pyrite treated compost samples recorded higher values of available sulfur. Available sulfur content of

the compost samples ranged from 0.08% in control,  $T_1$  to 2.11% in  $T_8$ .

#### Fulvic acid and Humic acid content

Lowest value of fulvic acid and humic acid were recorded in  $T_1$ , control (2.12% and 6.31 %, respectively) and highest in  $T_8$  (7.89% and 14.11%, respectively). Water hyacinth treated compost samples recorded higher values of humic and fulvic acid values as greater decomposition of these compost samples might have occurred resulting greater aromatic condensation. All the compost samples recorded higher values of humic acid and lower values of fulvic acid which is also the index of maturation of composts [6].

The results of the present investigation show that paddy straw and water hyacinth in 1 : 1 ratio when treated with mussoorie phosphate rock (MRP) @ 2.5%  $\text{P}_2\text{O}_5$  of the organic substrate and pyrites in the ratio of MRP : Pyrite of 1 : 1 improved the quality of compost with respect to microbial decomposition as well as mineralogical composition compared to that only paddy straw compost.

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