Synthesis and pot trial of organic fertilizer from solid waste

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Abstract. Organic farming nowadays is becoming popular and getting high attention worldwide.
This growing field needs many nutrient sources from natural resources since organic farming
cannot use synthetic fertilizer. Thus, many sources of nutrient-rich solids are being used to fulfill
the demand. Here, chicken feather powder, horn powder, poultry manure, and compost are used
for producing organic fertilizer. These solid waste materials are blended in various compositions,
i.e., horn plus poultry and horn plus compost. Selected fertilizer formulations were tested to grow
barley in a pot trial inside a glasshouse using several dosages. After about four weeks old, the
barley plant is harvested and weighed to determine the optimum fertilizer formula and dosage.
It appears that fertilizer formula using horn and poultry is the best fertilizer that can produce the
highest biomass in a respective time and compete with synthetic NPK fertilizer.

1. Introduction

By 2050, the agriculture and food sector of the world economy will have to increase 70% of their current
production to fulfill the food demands for 10 billion people, about 50% more than the present population
[1]. This challenge will be more difficult by unfavorable conditions such as climate change,
environmental degradation, loss of agricultural land, and intensifying competition from animal feed and
biofuel industries for human food. Indeed, some environmental degradation, such as eutrophication,
is worsened by conventional agricultural practices. Thus, organic farming is expected to become a future
trend worldwide for better food quality and minimizing environmental impact.

For supporting organic farming, a vast amount of natural materials is needed to fulfill the nutrient
demand. Nowadays, developed countries have already set a target of conventional farming replacement
by about 20% in the near future. They have utilized several high nutrient natural materials such as animal
horns, nails, and manures, but a vast amount of new natural resources is still needed for organic
fertilizers.

Meanwhile, poultry manure has high nutrients such as nitrogen (N), phosphor (P), potassium (K),
calcium (Ca), magnesium (Mg) and several other essential minerals for plants [2-3]. This material is
easy to be decomposed in nature while releasing the nutrient content [4]. Other manure, from cows or
buffalos, has high varieties of micronutrients beside high macronutrients such as Ca, Mg, S, Zn, B, Cu,
and Mn [5].

It has been reported that many natural under-utilized materials are able to increase the soil fertility
and structure, improve water retention capacity and microbial population in the soil [6-7]. Thus, in this
study, several high nutrient contents of natural materials, mostly from waste, are investigated by pot trial method using barley as a plant model for understanding the effect of the material in seedling period and plant growth.

2. Materials and method

The cocopeat was brought from a local organic farming store, soaked in water for one day, and dried before further used. Cocopeat was used for the main planting media. Several organic sources of macronutrients were prepared from natural wastes. Cow’s horns were heated in the oven at 200°C for 2 hours and milled to produce horn powder. Similarly, poultry manure is also dried and crushed. For compost preparation, the falling leaves on the streets around the UGM campus were collected and composted using a windrow system for 40 days. For feather powder preparation, the fresh chicken feathers waste was dried and heated inside an autoclave for 1 hour at a temperature of 150°C. Then, the steamed feathers were naturally dried and crushed by disc-mill. The nutrient content of each material is provided in table 1. N content of the materials was determined by Kjeldahl method, while P and K content was measured by EDXS (Shimadzu EDX-7000).

| Table 1. Nutrition of several organic materials and NPK inorganic (in %wt.) |
|-----------------|---|---|---|
|                | N  | P  | K  |
| Compost        | 0.8| 0.4| 0.7|
| Feather flour  | 2.0| 0.4| 1.6|
| Poultry manure | 3.5| 3.0| 0.9|
| Horn flour     | 13.0| 0.4| 0.3|
| NPK commercial | 15 | 15 | 15 |

Table 2 shows the formulation of planting media and the nomenclature. The prepared planting media was filled into pots that can contain 0.5L planting media of each. Every media formulation was prepared in three pots (triplicate). Then, 50 seeds of barley were added to each pot. All trial was watered regularly with the same amount of water about 50ml per day. The seedlings were harvested after the difference among the trials was clearly seen.

| Table 2. Planting media formulation and identification. |
|-----------------|---|---|---|
| Nutrition added (volume or weight) | Cocopeat volume (L) | Sample name (ID) |
| 1st TRIAL (29 days) | | |
| n.a.              | 2.0 | Control     |
| Compost (0.5 L)   | 1.5 | 25% compost |
| Compost (1.0 L)   | 1.0 | 50% compost |
| Horn (0.85 g) and poultry manure (0.85 g) | 2.0 | 1.7gr H+P |
| Horn (1.7 g) and poultry manure (1.7 g) | 2.0 | 3.4gr H+P |
| Horn (3.4 g) and poultry manure (3.4 g) | 2.0 | 6.8gr H+P |
| 2nd TRIAL (28 days) | | |
| n.a.              | 2.0 | Control     |
| poultry manure (1.7 g) | 2.0 | poultry     |
| Horn (1.7 g)       | 2.0 | horn        |
| Horn (0.85 g) and poultry manure (0.85 g) | 2.0 | H+P        |
| Horn (0.85 g) and compost (0.85 g) | 2.0 | H+C        |
| Compost (1.7 g)    | 2.0 | Compost     |
| Feather (1.7 g)    | 2.0 | Feather     |
| NPK (1.7 g)        | 2.0 | NPK         |
There were two times of planting trials. The first was done from 26 August to 23 September 2019 (29 days). Different composition of planting media was put in each pot then 50 seeds of barley were placed in each pot. The second trial planting date was 28 August to 25 September 2019 (28 days), with 50 seeds of barley being put in each pot.

3. Result and discussion
Table 3 shows the results of the first trial. In general, all added organic fertilizers have heavier biomass weight at the harvesting time except for 50Comp, which is slightly less than the control. For horn and poultry mixture, the more nutrient added, the better growth of barley biomass. However, the number of seedlings is significantly decreased at the highest dosage. It can be a hint of overpowering in nutrient for seedling.

Table 3. First pot trial data of seedling number and harvesting weight.

| Sample media ID | Pot no. | Number of seedlings | Seedlings weight (gram) |
|-----------------|---------|---------------------|-------------------------|
| Control         | 1       | 42                  | 7.13                    |
|                 | 2       | 47                  | 7.06                    |
|                 | 3       | 47                  | 8.22                    |
| 25% compost     | 1       | 46                  | 8.29                    |
|                 | 2       | 45                  | 8.5                     |
|                 | 3       | 45                  | 8.98                    |
| 50% compost     | 1       | 48                  | 6.86                    |
|                 | 2       | 46                  | 7.76                    |
|                 | 3       | 43                  | 6.6                     |
| 1.7gr H+P       | 1       | 44                  | 9.83                    |
|                 | 2       | 45                  | 9.44                    |
|                 | 3       | 43                  | 9.18                    |
| 3.4gr H+P       | 1       | 44                  | 12.5                    |
|                 | 2       | 45                  | 12.89                   |
|                 | 3       | 45                  | 12.74                   |
| 6.8gr H+P       | 1       | 46                  | 17.53                   |
|                 | 2       | 40                  | 16.69                   |
|                 | 3       | 45                  | 15.75                   |

Figure 1. The average number of seedlings and seedlings weight from trial 1.
For ease of comparison, the average data of the first trial is presented in figure 1. In terms of seedling number, the variation of a nutrient does not have a significant effect. Meanwhile, biomass production is affected by organic materials. The biomass weight increases more than two-fold with the highest nutrient addition (6.8gH+P). Some pictures of the first greenhouse pot trials are shown in figure 2.

**Figure 2.** Pot trial 1, a) Twenty (20) days old of barley seedlings, b) Harvested barley seedlings.

In the second trial, we compared among different types of the organic solid fertilizers and with commercial NPK. The result is shown in figure 3 and table 4. In general, the NPK is still superior to the rest of organic fertilizer. While for organic nutrients, the highest biomass weight is obtained by horn powder and then poultry. The mixture of horn and poultry does not show a better performance than the single material.

In terms of seedling number, the feather and compost show the least number, while the highest is obtained by the mixture of horn and compost. This mixture can be an excellent organic nutrient for seedling time, while for plant growth, the horn powder is the best nutrient so far.

From the result of the first and second trials, it can be seen that the commercial NPK (1.7 g) performance can be only outweighed by the mixture of horn and poultry but with a four-time dosage (6.8gr H+P). This can prove that the organic fertilizer is needed in a higher amount than the synthetic fertilizer since the nutrient content is much lower. The barley in pots and biomass harvested during the second trial are shown in figure 4.

| Sample media ID | Pot no. | Number of seedlings | Seedlings weight (gram) |
|-----------------|---------|---------------------|-------------------------|
| control         | 1       | 43                  | 7.98                    |
|                 | 2       | 43                  | 7.29                    |
|                 | 3       | 43                  | 7.12                    |
| Poultry         | 1       | 46                  | 8.46                    |
|                 | 2       | 45                  | 9                       |
|                 | 3       | 47                  | 8.24                    |
| Horn            | 1       | 49                  | 10.39                   |
|                 | 2       | 44                  | 8.96                    |
|                 | 3       | 44                  | 10.06                   |
| H+P             | 1       | 43                  | 8.61                    |
| Sample media ID | Pot no. | Number of seedlings | Seedlings weight (gram) |
|-----------------|--------|---------------------|------------------------|
|                 | 2      | 46                  | 7.62                   |
|                 | 3      | 43                  | 9.08                   |
| H+C             | 1      | 46                  | 7.84                   |
|                 | 2      | 50                  | 9.47                   |
|                 | 3      | 45                  | 7.94                   |
| compost         | 1      | 39                  | 6.45                   |
|                 | 2      | 40                  | 6.9                    |
|                 | 3      | 43                  | 7.1                    |
| feather         | 1      | 38                  | 7.05                   |
|                 | 2      | 39                  | 6.55                   |
|                 | 3      | 45                  | 6.82                   |
| NPK             | 1      | 43                  | 12.63                  |
|                 | 2      | 46                  | 15.44                  |
|                 | 3      | 46                  | 13.85                  |

**Figure 3.** Average number of seedlings and seedlings weight from trial 2.

**Figure 4.** Pot trial 2, a) Twenty-eight days old of barley seedlings, b) Harvested barley seedlings.
4. Conclusion
The organic fertilizer from many types of waste can substitute the demand for synthetic fertilizer. However, due to the low nutrient content, organic fertilizer should use in higher dosage to keep up with the conventional fertilizer.

5. Reference
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Acknowledgments
This publication is sponsored by RTA Grant UGM 2021 and PIAT research grants.