Effect of cow manure, neem compost and straw compost towards N uptake and soil fauna abundance in inceptisol paddy field, Berbah, Sleman

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Abstract. Maintenance of environmental production is important to increase rice production. This study aimed to determine the effects of organic fertilizers application on nitrogen uptake, nitrogen availability and the abundance of soil fauna in paddy field. This study used Randomized Complete Block Design (RCBD) factorial with combination treatments of cow manure, neem compost and straw compost in two kind of dosage application at 10 tons ha⁻¹ and 20 tons ha⁻¹ with three replications in each treatments. The total treatments were 14 and one control. The observed parameters were pH, soil organic matter, available-N, soil total N, total N and N-uptake in plant tissues, non-parasites nematode and agronomic observations. The data obtained from the experiment were analysed by analysis of variance using SAS 9.1 software. The differences of treatments have a significant effect in several chemical properties i.e. potential pH, soil organic matter, available-N, soil total N, plant total N and N-uptake, and biological properties. The results of N-uptake in the vegetative phase, as well as plant height and number of tillers indicate that the best dosage that can be achieved in this study was the application of neem compost 20 tons ha⁻¹ with rice production at 4.6 tons ha⁻¹.

1. Introduction
Rice (Oryza sativa) is the most important agricultural commodity in Indonesia. In addition, rice is also expected to become one of the main commodities contributing foreign exchange from the non-oil sector. Rice is one of the strategic commodities in Indonesia. This is related to the fact that the staple food of most Indonesians is rice. Rice is also become the major source of carbohydrates for the majority of the world's population. Indonesia still often faces food problems such as uncertain seasonal changes that could lead to a decline in rice production which requires the government to import rice to supply national needs. This condition is exacerbated by the economic crisis that affects the purchasing power of farmers to production facilities, especially fertilizers and pesticides [1]. To increase rice production need to do environmental preservation, one of them with the utilization of organic fertilizer [2]. Various forms and ingredients of organic fertilizers may be given depending on availability at the farm site. So far in some areas there are still many local resources that can be used as organic fertilizer, but not yet optimally utilized, including cow and sheep dung, even in some centers of livestock, the dung become source of environmental pollution. Fertilization becomes one of the important factors to increase rice production. It is encouraging to do research on the effect of cow manure, neem compost and straw compost towards nitrogen uptake and abundance of soil fauna in inceptisols paddy field in Berbah.
2. Materials and Methods

This research was conducted on March 2016 until August 2016 at Centre for Agricultural Innovation and Technology Universitas Gadjah Mada Kalitirto, Berbah, Sleman, Yogyakarta. This study used Randomized Complete Block Design (RCBD) factorial with combination treatments of cow manure, neem compost and straw compost in two kind of dosage application at 10 tons·ha$^{-1}$ and 20 tons·ha$^{-1}$ with three replications in each treatments. The data obtained from the experiment were analyzed by the analysis of the variance to determine the effect of each treatments. Planting system is done with three seeds per hole with 25 × 25 cm planting space. The varieties used were Inpari 23 rice. After harvesting period, the study continued with the preparation of soil and plant samples for analysis conducted at the General Soil Laboratory and Nematology Laboratory, Faculty of Agriculture, Universitas Gadjah Mada, Yogyakarta. The data obtained were tested using analysis of variance (ANOVA). If the treatments showed significant effect at level 5 %, then continued using DMRT (Duncan's Multiple Range Test) with 5 % significant level to know the difference between treatments.

3. Results and Discussion

3.1. Initial soil properties

Analysis of the initial soil properties was used to determine soil conditions before treatment. The initial soil properties analyzed include chemical properties (actual pH, potential pH, Organic-C, organic matter, KPK, N total, N available) and soil physics (soil texture). The following initial soil properties are presented in table 1.

| No | Parameters         | Unit   | Value | Level   |
|----|--------------------|--------|-------|---------|
| 1  | Actual-pH          | -      | 6.4   | Neutral |
| 2  | Potential-pH       | -      | 5.4   | -       |
| 3  | Organic Carbon     | %      | 1.08  | Low     |
| 4  | Organic Matter     | %      | 1.86  | -       |
| 5  | CEC                | cmol(+)-kg$^{-1}$ | 12.97 | Low     |
| 6  | Total-N            | %      | 0.05  | Very low|
| 7  | Available-N        | mg·g$^{-1}$ | 3.92  | Medium  |
|    | NH$_4^+$           | mg·g$^{-1}$ | 3.61  | Low     |
| 8  | Water Contain      | %      | 4.2   |         |
| 9  | Texture            |        | Sandy Loam |       |
|    | Sand               | %      | 56    |         |
|    | Silt               | %      | 26    |         |
|    | Clay               | %      | 16    |         |

Note: Level following Balittanah 2009.

Soil actual-pH obtained from initial soil analysis was 6.4 and potential-pH was 5.4. The potential-pH value is less than actual-pH because the amount of H$^+$ present in the soil solution is greater. The pH indicate that the rice plant is in good condition when planted in Inceptisols, because rice plants can grow optimally in the range of 5.5 to 7.0. The soil organic matter ranges from 0.5 to 5 % in mineral soils. The Organic-C in Inceptisols was 1.08 % while the organic material was 1.86 % which is low. The CEC value was 12.97 cmol(+)-kg$^{-1}$, this is influenced by clay mineral content, clay mineral type and soil organic matter content. The addition of organic matter will increase negative charge which result in the enhancement of CEC [3]. The initial soil analysis results showed ammonium (NH$_4^+$) was 3.92 mg·g$^{-1}$ and the nitrate (NO$_3^-$) was 3.61 mg·g$^{-1}$, while soil total-N is very low at 0.05 %. Generally
the nitrogen contained in the soil is low, so it must be added nitrogen in the form (organic or inorganic fertilizer) or other sources at the beginning of the planting period. Soil texture is the relative comparison between soil fractions, i.e. dust (silt), clay (clay) and sand (sand). The dominant fraction of the soil constituent is characteristic of a soil type in which the proportion of the constituent fraction of each will vary. Soil texture in the initial phase before treatment has a value of 56% sand, 26% for dust and 16% for clay. Based on the percentage of each fraction the initial soil composite has a turbidity texture according to the USDA texture triangle. Soil texture is one of the physical properties of the soil that is not easily changed.

3.2. Chemical properties of organic fertilizers
There are three kinds of organic fertilizer used in this research, cow manure, neem compost, and straw compost. Table 2 shows the chemical properties of those three organic fertilizers.

| No | Parameters  | Unit     | Cow Manure | Neem Compost | Straw Compost |
|----|-------------|----------|------------|---------------|---------------|
| 1  | pH          | -        | 7.08       | 4.8           | 8.10          |
| 2  | EC          | dS-m⁻¹   | 0.57       | 0.37          | 0.2           |
| 3  | Organic-C   | %        | 6.25       | 54.14         | 28.73         |
| 4  | C/N         |          | 27.17      | 22.46         | 19.68         |
| 5  | Total-N     | %        | 0.23       | 2.41          | 1.46          |
| 6  | P           | %        | 0.11       | 0.13          | 0.26          |
| 7  | K           | %        | 0.21       | 1.00          | 2.93          |

Note: at the time of analysis have not fulfilled minimum technical requirement of solid organic fertilizer according to Permentan No.70/Permentan/SR.140/10/2011.

Regulation of the Minister of Agriculture No.70 /Permentan/SR.140/10/2011 is a regulation concerning organic fertilizers, biological fertilizers and soil enhancers. The treatment of organic materials used in this study are cow manure, neem compost and straw compost. In this study, cow manure is enriched by Trichoderma, N-blocking bacteria and P solvent bacteria. Cow manure has been stored for 2 years. The result of fertilizer and compost analysis shows the pH value ranged 4 to 9, it is corresponding the minimum technical standard of organic fertilizer. The EC value of cow manure is 0.57 dS-m⁻¹, neem compost is 0.37 dS-m⁻¹ and straw compost is 0.2 dS-m⁻¹. Organic carbon of cow manure was 6.25 %, neem compost was 54.14 % and straw compost was 28.73 %. The OC of neem compost and straw compost has the suitable result following Permentan standard of organic fertilizers (OC minimum ≥ 12 %). While the organic carbon of cow manure were too low according to requirements of Permentan No.70/Permentan/SR.140/5/2011, this is because the N loss in cow manure due to evaporation, because it stored for ± 2 years. Total N of cow manure was 0.23 %, neem compost was 2.41 % and compost of straw was 1.46 %, this results were low according to Permentan No. 70. The results of C/N ratio of neem and straw compost were suitable following the standard of Permentan, while the cow manure was not. For elements P and K suit to the minimum standards that is less than 6 %.

3.3. Effect of organic fertilizers treatments on soil chemical properties

3.3.1. Actual and potential pH. Based on the results of ANOVA, there’s no significant effect on the actual pH after the application of organic fertilizers, while in the potential pH there was significantly different in generative phase.
Table 3. Soil pH in in vegetative and generative phases.

| Treatments                          | Actual | Potential |
|-------------------------------------|--------|-----------|
|                                     | Vegetative | Generative | Vegetative | Generative |
| Cow Manure 10 tons·ha⁻¹             | 6.30 ab  | 6.64 a     | 5.35 ab  | 5.79 ab    |
| Cow Manure 20 tons·ha⁻¹             | 6.40 ab  | 6.70 a     | 5.61 ab  | 5.69 ab    |
| Neem Compost 10 tons·ha⁻¹           | 6.07 b   | 6.81 a     | 5.67 ab  | 5.66 ab    |
| Neem Compost 20 tons·ha⁻¹           | 6.33 ab  | 6.58 a     | 5.60 ab  | 5.56 b     |
| Straw Compost 10 tons·ha⁻¹          | 6.23 ab  | 6.56 a     | 5.57 ab  | 5.49 b     |
| Straw Compost 20 tons·ha⁻¹          | 6.23 ab  | 6.83 a     | 5.68 ab  | 5.63 ab    |
| Cow Manure 5 tons·ha⁻¹ + Neem Compost 5 tons·ha⁻¹ | 6.27 ab  | 6.63 a     | 5.76 a   | 5.77 ab    |
| Cow Manure 10 tons·ha⁻¹ + Neem Compost 10 tons·ha⁻¹ | 6.30 ab  | 6.79 a     | 5.84 a   | 5.95 ab    |
| Cow Manure 5 tons·ha⁻¹ + Straw Compost 5 tons·ha⁻¹ | 6.23 ab  | 6.46 a     | 5.90 a   | 5.77 ab    |
| Cow Manure 10 tons·ha⁻¹ + Straw Compost 10 tons·ha⁻¹ | 6.37 ab  | 6.55 a     | 5.94 a   | 5.67 ab    |
| Straw Compost 5 tons·ha⁻¹ + Neem Compost 5 tons·ha⁻¹ | 6.33 ab  | 6.56 a     | 5.77 a   | 5.53 b     |
| Straw Compost 10 tons·ha⁻¹ + Neem Compost 10 tons·ha⁻¹ | 6.23 ab  | 6.79 a     | 5.83 a   | 5.53 b     |
| Straw Compost 2.5 tons·ha⁻¹ + Neem Compost 2.5 tons·ha⁻¹ + Cow Manure 2.5 tons·ha⁻¹ | 6.00 b   | 6.48 a     | 5.53 ab  | 5.67 ab    |
| Straw Compost 5 tons·ha⁻¹ + Neem Compost 5 tons·ha⁻¹ + Cow Manure 5 tons·ha⁻¹ | 6.30 ab  | 6.6 a      | 5.38 ab  | 5.69 ab    |
| Control                             | 6.47 ab  | 6.50 a     | 5.10 b   | 5.12 c     |

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5%.

The increment of soil pH undergo when the organic materials added to the soil already decomposed, because the mineralized organic materials will release their base cations [3]. In addition, during the planting period, soil will be in waterlogged condition and it makes the soil become reduced that could increase the pH. The addition of different kind and dosage of organic fertilizers has significant effect on the potential pH in generative phase. Potential pH has the lower result than actual pH because of the amount of H⁺ present in soil solution is higher.

3.3.2. Soil organic matter. The result of statistical analysis showed that the treatments of different type and dosage of organic fertilizer had no significant effect on organic-C on the vegetative phase, but in the generative phase there was a significant effect on organic-C. Table 4 shows the results of the variation in the vegetative phase and the generative phase of the soil organic matter as follows:

Table 4. Soil organic carbon in the vegetative and generative phases.

| Soil Organic Matter (%) | Treatments | Vegetative | Generative |
|-------------------------|------------|------------|------------|
| Cow Manure 10 tons·ha⁻¹ | 3.01 a     | 2.28 a     |
| Cow Manure 20 tons·ha⁻¹ | 2.41 a     | 2.42 a     |
| Neem Compost 10 tons·ha⁻¹ | 1.64 a   | 2.15 ab    |
| Neem Compost 20 tons·ha⁻¹ | 3.17 a   | 2.33 a     |
Straw Compost 10 tons·ha\(^{-1}\) & 2.65 a & 2.51 a \\
Straw Compost 20 tons·ha\(^{-1}\) & 3.03 a & 2.15 ab \\
Cow Manure 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) & 2.88 a & 2.51 a \\
Cow Manure 10 tons·ha\(^{-1}\) + Neem Compost 10 tons·ha\(^{-1}\) & 2.78 a & 2.60 a \\
Cow Manure 5 tons·ha\(^{-1}\) + Straw Compost 5 tons·ha\(^{-1}\) & 2.94 a & 2.29 a \\
Cow Manure 10 tons·ha\(^{-1}\) + Straw Compost 10 tons·ha\(^{-1}\) & 2.78 a & 2.51 a \\
Straw Compost 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) & 2.61 a & 2.33 a \\
Straw Compost 10 tons·ha\(^{-1}\) + Neem Compost 10 tons·ha\(^{-1}\) & 2.45 a & 2.55 a \\
Straw Compost 2.5 tons·ha\(^{-1}\) + Neem Compost 2.5 tons·ha\(^{-1}\) + Cow Manure 2.5 tons·ha\(^{-1}\) & 2.73 a & 2.64 a \\
Straw Compost 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) + Cow Manure 5 tons·ha\(^{-1}\) & 2.91 a & 2.33 a \\
Control & 2.73 a & 1.70 b \\

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5%.

The results indicate that the influence of different types and dosages of organic fertilizers did not give a significant effect for soil organic matter in the vegetative phase. In the generative phase shows that the effect of different types and dosages of organic fertilizers gives a significant effect on the soil organic matter. The role of organic matter will be more prominent, where the soil organic carbon content in intensively cultivated paddy fields tend to be at the low level, i.e. less than 2% [4]. The higher the addition of organic fertilizer, the content of organic materials supplied will increase as well.

3.3.3. Total nitrogen. The results of the analysis of variance showed the treatment of different types and dosages of organic fertilizer gave a significant effect to total soil N on the vegetative phase as well as in the generative phase. Table 5 shows the results of the variation in the vegetative phase and the generative phase of total nitrogen as follows:

**Table 5. Soil total N in the vegetative and generative phases.**

| Treatments                                      | Vegetative (%) | Generative (%) |
|-------------------------------------------------|----------------|----------------|
| Cow Manure 10 tons·ha\(^{-1}\)                  | 0.04 cd        | 0.06 cdef      |
| Cow Manure 20 tons·ha\(^{-1}\)                  | 0.06 bc        | 0.07 bcde      |
| Neem Compost 10 tons·ha\(^{-1}\)               | 0.08 ab        | 0.08 bcd       |
| Neem Compost 20 tons·ha\(^{-1}\)               | 0.10 a         | 0.12 a         |
| Straw Compost 10 tons·ha\(^{-1}\)              | 0.05 d         | 0.06 cdef      |
| Straw Compost 20 tons·ha\(^{-1}\)              | 0.08 ab        | 0.08 bc        |
| Cow Manure 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) | 0.06 ab | 0.09 b    |
| Cow Manure 10 tons·ha\(^{-1}\) + Neem Compost 10 tons·ha\(^{-1}\) | 0.08 d | 0.05 f    |
| Cow Manure 5 tons·ha\(^{-1}\) + Straw Compost 5 tons·ha\(^{-1}\) | 0.05 cd | 0.06 bcde   |
| Cow Manure 10 tons·ha\(^{-1}\) + Straw Compost 10 tons·ha\(^{-1}\) | 0.07 bc | 0.05 def   |
| Straw Compost 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) | 0.06 bc | 0.08 bc    |
| Straw Compost 10 tons·ha\(^{-1}\) + Neem Compost 10 tons·ha\(^{-1}\) | 0.07 bc | 0.08 bcd   |
| Straw Compost 2.5 tons·ha\(^{-1}\) + Neem Compost 2.5 tons·ha\(^{-1}\) + Cow Manure 2.5 tons·ha\(^{-1}\) | 0.08 ab | 0.06 cdef  |
| Straw Compost 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) + Cow Manure 5 tons·ha\(^{-1}\) | 0.07 bc | 0.06 cdef  |
| Control                                         | 0.05 cd        | 0.04 cf        |

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5%.
Based on result of analysis of variance indicate that the addition of different type and dosage of organic fertilizer give significant effect to total N both in vegetative phase and in generative phase. Nitrogen in the soil is derived from organic matter, atmospheric nitrogen fixation by microbes, fertilizers and rainwater. Generally, soil total-N is low, thus the addition of N fertilizers is important at the beginning of planting period. In addition, Nitrogen is very mobile (easily changed from other forms such as NH$_4^+$ to NO$_3^-$, NO, N$_2$O and N$_2$), easily vaporized and leached by drainage and difficult to be utilized by plants [5].

3.3.4. Available nitrogen. The result of the analysis of variance showed that the treatment of different types and dosages of organic fertilizer in the vegetative and generative phases gave a significant effect on the N available soil. Table 6 shows the results of the variance in the vegetative and generative phases against the N available soil as follows:

**Table 6.** Soil N available in the vegetative and generative phases.

| Treatments                        | Ammonium NH$_4^+$ (mg·g$^{-1}$) | Nitrate NO$_3^-$ (mg·g$^{-1}$) |
|-----------------------------------|----------------------------------|-------------------------------|
|                                   | Vegetative | Generative | Vegetative | Generative |
| Cow Manure 10 tons·ha$^{-1}$      | 4.67 ef    | 3.76 o     | 4.67 d     | 3.76 o     |
| Cow Manure 20 tons·ha$^{-1}$      | 9.36 cdef  | 7.45 j     | 7.02 cd    | 7.45 j     |
| Neem Compost 10 tons·ha$^{-1}$    | 4.78 ef    | 7.72 h     | 8.10 cd    | 7.72 i     |
| Neem Compost 20 tons·ha$^{-1}$    | 12.87 bcde | 18.24 d    | 26.11 a    | 14.60 g    |
| Straw Compost 10 tons·ha$^{-1}$   | 8.16 def   | 4.06 m     | 4.67 d     | 33.30 a    |
| Straw Compost 20 tons·ha$^{-1}$   | 14.30 abcd | 7.40 k     | 8.32 cd    | 20.32 d    |
| Cow Manure 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$ | 17.57 abc  | 7.85 g     | 8.25 cd    | 24.76 c    |
| Cow Manure 10 tons·ha$^{-1}$ + Neem Compost 10 tons·ha$^{-1}$ | 9.42 cdef  | 22.49 c    | 14.01 bcd  | 7.50 k     |
| Cow Manure 5 tons·ha$^{-1}$ + Straw Compost 5 tons·ha$^{-1}$ | 5.86 def   | 7.271      | 5.86 d     | 31.01 b    |
| Cow Manure 10 tons·ha$^{-1}$ + Straw Compost 10 tons·ha$^{-1}$ | 17.79 abc  | 27.14 a    | 7.15 cd    | 10.91 h    |
| Straw Compost 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$ | 9.43 cdef  | 11.01 e    | 17.69 abc  | 7.34 m     |
| Straw Compost 10 tons·ha$^{-1}$ + Neem Compost 10 tons·ha$^{-1}$ | 22.49 a    | 7.68 i     | 25.92 a    | 7.68 j     |
| Straw Compost 2.5 tons·ha$^{-1}$ + Neem Compost 2.5 tons·ha$^{-1}$ | 10.65 cdef | 7.87 f     | 19.87 ab   | 19.66 e    |
| Straw Compost 5 tons·ha$^{-1}$ + Cow Manure 2.5 tons·ha$^{-1}$ | 21.03 ab   | 25.92 b    | 9.39 cd    | 18.51 f    |
| Control                          | 3.62 f     | 4.01 n     | 3.62 d     | 4.01 n     |

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5 %.

Based on result of analysis of variance indicate that giving of different type and dosage of organic fertilizer give significant effect on availability of ammonium and nitrate both in vegetative and generative phase. Nitrogen (N) are absorbed by plant roots in the form of ammonium (NH$_4^+$) and nitrate (NO$_3^-$), as well as more complex materials such as water-soluble amino acids and nucleic acids. The higher the dosage of organic fertilizer, the NO$_3^-$ value in the soil is also higher because of the reshuffle of organic matter will produce nitrogen elements in the form of NO$_3^-$, NH$_4^+$ and NO$_2^-$ [6].
3.4. Effect of organic fertilizer treatment on soil biological properties

3.4.1. Non-parasitic nematodes. The result of the analysis of variance showed that different types and dosages of organic fertilizer did not give significant effect to the abundance of non-parasitic soil nematodes in the vegetative and generative phase. Figure 1 shows the results of the variance in the vegetative and generative phase of non-parasitic soil nematodes.

![Figure 1. Soil non-parasitic Nematodes in the vegetative and generative phase.](image)

The results indicate the application of organic fertilizers has no significant effect to the abundance of non-parasitic soil nematodes. When nematodes consume bacteria or fungi, ammonium ions ($\text{NH}_4^+$) are released because bacteria and fungi contain more nitrogen than required by nematodes. Nematodes have a contribution on nutrient cycles, controlling the balance between bacteria and fungi and the composition of microbial communities, support the distribution of bacteria and fungi, food sources and suppressing disease sources [7].

3.5. Effect of organic fertilizer on total N and N uptake in plant tissue

3.5.1. Total N in plant tissue. The result of the analysis of variance showed that the different types and dosages of organic fertilizer gave a significant effect on total N content in plant tissue at vegetative and generative phase. Table 7 shows the results of the variation in vegetative and the generative phase of total N content in plant tissue as follows:

| Treatments                  | Vegetative shoots | Generative roots | Vegetative shoots | Generative roots |
|-----------------------------|-------------------|------------------|-------------------|------------------|
| Cow Manure 10 tons·ha$^{-1}$| 0.37 ef           | 0.28 e           | 0.37 de           | 0.56 bc          |
| Cow Manure 20 tons·ha$^{-1}$| 0.65 bcd          | 0.65 bcd         | 0.56 cd           | 0.75 ab          |
| Neem Compost 10 tons·ha$^{-1}$| 0.56 cde          | 0.65 bcd         | 0.65 bc           | 0.65 ab          |
| Neem Compost 20 tons·ha$^{-1}$| 1.49 a            | 1.30 a           | 0.93 a            | 0.84 a           |
| Straw Compost 10 tons·ha$^{-1}$| 0.65 bcd          | 0.56 cde         | 0.65 bc           | 0.75 ab          |
| Straw Compost 20 tons·ha$^{-1}$| 0.84 a            | 0.84 bc          | 0.75 abc          | 0.84 a           |
| Cow Manure 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$| 0.47 def          | 0.45 de          | 0.56 cd           | 0.65 ab          |
Cow Manure 10 tons·ha$^{-1}$ + Neem Compost 10 tons·ha$^{-1}$  0.47 def  0.65 bcd  0.84 ab  0.75 ab
Cow Manure 5 tons·ha$^{-1}$ + Straw Compost 5 tons·ha$^{-1}$  0.65 bcd  0.75 bcd  0.65 bc  0.65 ab
Cow Manure 10 tons·ha$^{-1}$ + Straw Compost 10 tons·ha$^{-1}$  0.75 bc  0.75 bcd  0.75 abc  0.75 ab
Straw Compost 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$  0.56 cde  0.93 b  0.56 cd  0.84 a
Straw Compost 10 tons·ha$^{-1}$ + Neem Compost 10 tons·ha$^{-1}$  0.84 a  0.75 bcd  0.75 abc  0.84 a
Straw Compost 2.5 tons·ha$^{-1}$ + Neem Compost 2.5 tons·ha$^{-1}$ + Cow Manure 2.5 tons·ha$^{-1}$  0.65 bcd  0.75 bcd  0.84 ab  0.84 a
Straw Compost 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$ + Cow Manure 5 tons·ha$^{-1}$  1.49 a  1.30 a  0.75 abc  0.84 a
Control  0.28 f  0.28 e  0.28 e  0.37 c

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5%.

The table above indicate that addition of different type and dosage of organic fertilizer give significant effect on N uptake in plant tissue either in vegetative or generative phase. The average of nitrogen content in plant tissue is 2–4 % dry weight [8]. Morphological character of each varieties of rice plants is different, so the response of rice varieties in utilizing N will also different.

3.5.2. $N$ uptake in plant tissue. The result of the analysis of variance showed that the treatment of different types and dosages of organic fertilizer gave a significant effect on N uptake in plants in the vegetative phase and generative phase (shoots). Table 8 shows the results of the variance of vegetative and generative phase of total N content in plant tissue as follows:

**Table 8. Rice N uptake in vegetative and generative phases.**

| Treatments | Vegetative shoots | Generative roots | Vegetative shoots | Generative roots |
|------------|------------------|------------------|------------------|------------------|
| Cow Manure 10 tons·ha$^{-1}$ | 5.55 b | 2.63 b | 16.52 cd | 9.33 bcd |
| Cow Manure 20 tons·ha$^{-1}$ | 5.69 b | 2.79 b | 22.59 bcd | 8.21 cd |
| Neem Compost 10 tons·ha$^{-1}$ | 6.07 b | 3.65 b | 27.16 bcd | 12.60 abcd |
| Neem Compost 20 tons·ha$^{-1}$ | 38.04 a | 20.49 a | 43.40 a | 27.16 abc |
| Straw Compost 10 tons·ha$^{-1}$ | 8.09 b | 3.89 b | 25.29 bcd | 22.59 abcd |
| Straw Compost 20 tons·ha$^{-1}$ | 12.18 b | 4.99 b | 24.36 bcd | 28.00 ab |
| Cow Manure 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$ | 12.53 b | 5.66 b | 24.45 bcd | 25.39 abcd |
| Cow Manure 10 tons·ha$^{-1}$ + Neem Compost 10 tons·ha$^{-1}$ | 7.97 b | 4.90 b | 29.96 abc | 14.65 abcd |
| Cow Manure 5 tons·ha$^{-1}$ + Straw Compost 5 tons·ha$^{-1}$ | 10.58 b | 4.48 b | 25.67 bcd | 11.67 abcd |
| Cow Manure 10 tons·ha$^{-1}$ + Straw Compost 10 tons·ha$^{-1}$ | 12.40 b | 6.12 b | 25.20 bcd | 12.13 abcd |
| Straw Compost 5 tons·ha$^{-1}$ + Neem Compost 5 tons·ha$^{-1}$ | 6.19 b | 5.32 b | 19.60 bcd | 17.08 abcd |
Straw Compost 10 tons·ha\(^{-1}\) + Neem Compost 10 tons·ha\(^{-1}\) & 11.01 b & 5.05 b & 28.47 bcd & 16.80 abcd \\
Straw Compost 2.5 tons·ha\(^{-1}\) + Neem Compost 2.5 tons·ha\(^{-1}\) + Cow Manure 2.5 tons·ha\(^{-1}\) & 6.96 b & 5.52 b & 2.48 ab & 29.96 a \\
Straw Compost 5 tons·ha\(^{-1}\) + Neem Compost 5 tons·ha\(^{-1}\) + Cow Manure 5 tons·ha\(^{-1}\) & 30.13 a & 13.57 ab & 25.76 bcd & 12.04 abcd \\
Control & 2.19 b & 1.89 b & 14.09 d & 7.65 d \\

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5%.

Based on the results of analysis of variance showed that giving different types and dosages of organic fertilizers gave a significant effect on N uptake in plants both in the vegetative phase and in the generative phase (shoots). The difference N uptake in shoots and root is due to the difference of N necessities in shoots and roots although the soil N conditions are the same [9].

### 3.6. Plant growth and production

#### 3.6.1. Plant height

Plant height observations are carried out once every week until the maximum vegetative growth. The observation of plant height is aimed to know the growth of plants between treatment of different type and dosage of organic fertilizer.

![Plant height during the growth of rice](image)

**Figure 2.** Plant height during the growth of rice.

Based on the picture above (Figure 2), the 20 tons·ha\(^{-1}\) dosage of neem compost gives the highest effect on plant growth which is shown by the increment of plant height compared to other treatments. In the fourth week after planting the influence of the dosage of fertilizer is high. The higher the dosage of organic fertilizer results in higher plant height [10].

#### 3.6.2. Roots and shoots fresh weight

Plant growth measured by fresh weight and dry weight is aimed to link the existing plant nutrient with plant growth. Figures 3 and 4 are the result of fresh weight of roots and shoots in vegetative phase and after harvest (generative).
Figure 3. Fresh weight of rice plant roots in vegetative and generative phase.

Figure 4. Fresh weight of rice plant shoots in vegetative and generative phase.

The highest root fresh weight was in 20 tons·ha\(^{-1}\) dosages of neem compost treatment at 53.49 g in vegetative phase and 73.33 g in generative phase. The highest fresh weight of the plant shoots is also found in 20 tons·ha\(^{-1}\) of neem compost at 103.73 g in vegetative phase and 226 g in generative phase. The fresh weight of plant illustrates the amount of photosynthesis result and water contained within the plant tissue. Fresh weight is influenced by environmental conditions, such as soil moisture and nutrients to support the growth of plants. The amount of fresh weight is directly proportional to the content of nutrients and water in the plant. The higher the fresh weight indicates the amount of nutrients and water content in the plants that can be absorbed.
3.6.3. Dry weight root and heading

Figure 5. Dry weight of rice plant roots in the vegetative and generative phases.

Figure 6. Dry weight of roots of rice plants in the vegetative and generative phases.

Figure 5 and 6 shows the results of root and shoots dry weight in vegetative and generative phase. In vegetative phase, the highest result of roots and shoots dry weight was found in 20 tons·ha\(^{-1}\) of neem compost at 15.63 g and 32.45 g. The highest result of roots and shoots dry weight in generative phase were also found in 20 tons·ha\(^{-1}\) of neem compost at 35.67 g and 50.33 g. Plant growth is irreversible process of increasing the size and dry weight of plants. The increase in the size and dry weight of an organism reflects the increase in protoplasm. This addition is due to the increasing size of plant organs such as plant height and stem diameter as a result of plant metabolism which is also influenced by environmental factors in planting areas such as temperature, sunlight, water, and nutrients in the soil. Growth and development are also influenced by genetic factors of these plants [11].
3.7. Rice production

Table 9. Rice grain harvest after treatments.

| Treatments | Dray grain harvest (tons·ha⁻¹) |
|------------|--------------------------------|
| Cow Manure 10 tons·ha⁻¹ | 1.6 b |
| Cow Manure 20 tons·ha⁻¹ | 1.3 b |
| Neem Compost 10 tons·ha⁻¹ | 3.5 ab |
| Neem Compost 20 tons·ha⁻¹ | 4.6 a |
| Straw Compost 10 tons·ha⁻¹ | 1.9 b |
| Straw Compost 20 tons·ha⁻¹ | 2.3 ab |
| Cow Manure 5 tons·ha⁻¹ + Neem Compost 5 tons·ha⁻¹ | 2.6 ab |
| Cow Manure 10 tons·ha⁻¹ + Neem Compost 10 tons·ha⁻¹ | 3.7 ab |
| Cow Manure 5 tons·ha⁻¹ + Straw Compost 5 tons·ha⁻¹ | 2.4 ab |
| Cow Manure 10 tons·ha⁻¹ + Straw Compost 10 tons·ha⁻¹ | 2.0 b |
| Straw Compost 5 tons·ha⁻¹ + Neem Compost 5 tons·ha⁻¹ | 1.9 b |
| Straw Compost 10 tons·ha⁻¹ + Neem Compost 10 tons·ha⁻¹ | 2.2 b |
| Straw Compost 2.5 tons·ha⁻¹ + Neem Compost 2.5 tons·ha⁻¹ + Cow Manure 2.5 tons·ha⁻¹ | 3.5 ab |
| Straw Compost 5 tons·ha⁻¹ + Neem Compost 5 tons·ha⁻¹ + Cow Manure 5 tons·ha⁻¹ | 2.6 ab |
| Control | 1.6 b |

Note: the number followed by the same letter in the same column shows no significant difference between treatments at level 5%.

Based on the results of analysis of variance indicate that the effect of different types and dosages of organic fertilizers did not give significant results but there is an interaction between treatments. The highest yield of dry grain is at 20 tons·ha⁻¹ of neem compost at 4.6 tons·ha⁻¹, while the lowest yield is in 20 tons·ha⁻¹ of cow manure treatment by 1.3 tons·ha⁻¹. The addition of organic matter to the farming system not only improve crop yields, but also improve soil fertility and lead to sustainable farming systems [12]. The results obtained on neem compost treatment 20 tons·ha⁻¹ and 10 tons·ha⁻¹ did not show much different results. Therefore, the use of 20 tons·ha⁻¹ of neem compost is considered less economical, because the addition of twice dosage did not give the significant different results. The use of 10 tons·ha⁻¹ of neem compost can also be replaced by mixing it with a combination of 2.5 tons·ha⁻¹ of straw compost, 2.5 tons·ha⁻¹ of neem compost and 2.5 tons·ha⁻¹ cow manure, which can reduce costs due to use residual harvesting straw and cow manure. Mixing is also considered more economical because use the lower dosages but give the same results.

3.8. Effect of soil biological properties on soil available N, N uptake and rice production effect of abundance of non-parasitic nematode on soil available N

The results of non-parasitic nematode abundance related to the N available soil in various treatments of organic fertilizers are presented in figure 8 as follows:
Figure 7. The relationship between abundance of non-parasitic nematodes and N available soil.

Based on figure 7, it can be seen that the abundance of non-parasitic nematodes has an effect on soil available N. The R value of relationship between non-parasitic nematode abundance and available N is 0.4438, which means the abundance of non-parasitic nematodes has a moderate positive relationship with N available. This results prove that the abundance of non-parasitic nematodes contributes to the availability of N in the soil. Bacterial and fungal-eating nematodes have N (nitrogen) content that can increases the N availability in soil [13]. Nematodes are one of the soil fauna (microfauna) that plays an important role in mineralization or nutrient release in available form to the plant. When nematodes consumes bacteria or fungi, ammonium ions (NH$_4^+$) are released because bacteria and fungi contain more nitrogen than required by nematodes [7].

3.9. The effect of the abundance of non-parasitic nematode on N uptake

The results of the non-parasitic nematode abundance were associated with the N available soil in various treatments of organic fertilizers presented in figure 9 as follows:

Figure 8. The relationship between abundance of non-parasitic nematode and N uptake of rice plants.
Abundance of non-parasitic nematodes also affected the N uptake of plant tissue. The value of R in figure 8 is 0.5504, which means that the abundance of non-parasitic nematodes has a sufficient positive influence on N uptake of plant tissue. If the amount of available N in the soil increases then further absorption of N by plant tissue will also increase. Well-processed compost will contain beneficial nematodes such as bacterial and fungal-eating nematodes. The function of bacterial and fungal-eating nematodes is to release elements of N, P, S and micronutrients that will be valuable to plants. This nematode will also delay the ability of root-eating nematodes in finding roots. If this type is abundant then more nutrient cycles [14].

3.10. Effect on N uptake on paddy production

The result of relationship between N uptake to rice production on various treatments of organic fertilizers presented in figure 10 as follows:

Based on figure 9, it appears that N uptake has an effect on the rice production. The value of R in figure 10 is 0.7317 which means a strong positive relationship between N uptake and rice production. This is because the nitrogen in the plant functions in expanding the leaf area to increase photosynthesis [15].

Rice production in this study is quite strong, although the location of experiment is in the first years of transition from conventional to organic field, the production was quite optimal. In general, When inpari 23 conventionally cultivated can achieve production of 9.2 tons, in this study we can achieve 4.6 tons·ha⁻¹. This indicates that the use of organic fertilizer in the beginning of conversion of conventional to organic land can produce optimal production, because the release of nutrients from organic materials takes sufficient time, so it can be directly absorbed by the plant. Organic farming when applied continuously can improve soil fertility and rice production.

4. Conclusion

Types and dosages of organic fertilizer have a significant effect on improving soil CEC, potential pH, Soil Organic Matter, available N, soil total N and N-uptake to improve soil fertility and rice production. N-uptake in the vegetative phase, as well as plant height and number of tillers indicate that the best dosage that can be achieved in this study is the application of neem compost 20 tons·ha⁻¹ with rice production at 4.6 tons·ha⁻¹.
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