Effect of vermicompost on yield and quality of Kemloko tobacco

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Abstract. The role of organic fertilizer is essential as an ameliorant of soil for tobacco cultivation. This study aimed to determine the effect of organic fertilizer types and N fertilizer on soil chemical characteristics, yield, and quality of tobacco. The study was carried out in the field experimental station, located in Glapansari village of Temanggung in 2017. The research was arranged in a split-plot design with two factors and three replications. The first factor as the main plot is two organic fertilizer types (vermicompost and manure). The second factor as the subplot is N fertilizer consisting of three levels (90, 120, and 150 kg N ha⁻¹). The result showed that the effect of vermicompost and manure was not significantly different on soil chemicals, except on soil C content. At the same level of N rate, vermicompost gave a higher tobacco yield than manure fertilizer. Vermicompost with the lowest N level (90 kg kg N ha⁻¹) produced a high tobacco crop index (crop value index). Vermicompost can reduce inorganic N fertilizer input and could be used as an ameliorant of tobacco dryland.

Keywords: vermicompost, tobacco, ameliorant

1. Introduction

Tobacco is a high-value economic commodity, and it is cultivated mostly in dryland by farmers in Temanggung, Central Java. Tobacco products are the main source of income of the farmers so that the crop is managed intensively even they are planted on land with a slope of more than 45% with no proper soil conservation practices [1]. Consequently, soil erosion is high, and soil fertility degradation is a common phenomenon found in the Temanggung dryland. The soil organic content in Temanggung is dominantly by low and intermediate criteria [2].

Farmers in Temanggung are used to adding stable manure as a source of organic matter with 20 – 30 tons per hectare [3]. The farmers import stable manure from other districts at a high price. There is an urgent need to provide another source of organic matter with better quality and cheaper than stable manure.

Vermicompost is composting with high nutrient content and product of microbiologically active soil amendment that results from the activity of earthworms and microorganisms in the breakdown process of the organic matter [4]. The quality of vermicompost is better than that of stable manure because it is more diverse and higher in the microbial population [5,6]. Other characteristics of vermicompost can decrease environmental pollution and detoxify some toxic chemicals, and contain quantities of plant-available nutrients, disease-suppressive microbial organisms, humic acids, and plant growth-regulating hormones [7, 8, 9].
Compared to stable manure application, the addition of vermicompost is more practical and applicable [10], and also it is easier to be transported to the field due to its lesser water content [11]. Furthermore, [12] reported that vermicompost contained N, P, and K nutrients 5 up to 11 times higher than soil. Thus, it could be applied in tobacco cultivation to minimize the use of chemical fertilizer. Unfortunately, there is less information about the effectiveness of vermicompost on the yield and quality of tobacco. The goal of the research was to measure the effect of vermicompost and different dose of N fertilizer on the growth, yield, and quality of tobacco.

2. Materials and methods
The field research was conducted at Glapansari village of Temanggung, Central Java, from March up to December 2017. The treatments consisted of two factors, i.e., organic fertilizer (stable manure/cow waste and vermicompost) and three levels of N fertilizer rate (90, 120, and 150 kg N ha$^{-1}$). The combination of treatments was arranged using Split Plot Design with three replicates. Organic matter sources were laid out as main plots, and N fertilizer rates were randomly put in subplots.

The local tobacco variety of Kemloko 2 was planted with a space size of 100 cm x 60 cm. Firstly, tobacco seeds were grown in seeding beds for 45 days, and then they were transplanted to the field. Organic matters with the rate equivalent to 22.5 tons ha$^{-1}$ were added three days before tobacco seedlings were transplanted by placing them into the planting holes. N-ammonium fertilizer with the rate according to the treatments were added twice, at 7 and 25 days after transplanting. All treatments plots received basal fertilizer 36 kg P$_2$O$_5$ and 90 kg K$_2$O ha$^{-1}$.

The observation was done on parameters of soil C-organic, NPK nutrients absorption, leave size, fresh yield, dried yield, grade index, and crop index. Bulked soil sample for soil C-organic analysis was collected at ten points in each treatment plot after harvested tobacco. The sample was taken from planting holes and air-dried and sieved before analyzing the soil based on Walky Black Method. Nutrient absorption was measured on dried biomass of tobacco plant, which was collected after harvesting tobacco finished.

Tobacco was harvested gradually up to six times based according to leaves maturity. In each harvesting time, the leaves were weighed, and the total six weighing tobacco leaves were recorded as fresh yield. Then, the freshly harvested tobacco leaves were processed by fermenting, slicing, and drying them in an open-air field. Dried tobacco was weighed as dried yield. The quality of tobacco and it's price were determined by the grader of the cigarette factory, and it was expressed by the parameter of Grade Index (GI). Commodity value was indicated by the parameter of crop index, which was calculated by multiplying grade index and dried yield.

Collected data were calculated for ANOVA, and the significant difference of each treatment was compared using Least Significant Different at p<0.05.

3. Results and discussion
The field soil used in the research is categorized as low in soil nutrients contents as indicated by very low in P and K contents, and low in N contents (Table 1). The soil texture is silty loam with sand, silt, and clay contents of 41%, 52%, and 7%, respectively.

| No | Type of Analysis | Unit | Result | Criteria$^1$ |
|----|-----------------|------|--------|--------------|
| 1. | pH $\text{H}_2\text{O}$ |      | 5.0    | Acid         |
|    | pH KCl 1 N      |      | 4.8    |              |
| 2. | C-organic (%)   |      | 2.06   | Intermediate |
| 3. | N-total (%)     |      | 0.18   | Low          |
| 4. | C/N             |      | 11     | Intermediate |
| 5. | P.Bray (mg kg$^{-1}$) | 0.76  | Very low |
| 6. | K (me.100g$^{-1}$) | 0.53  | Very low |
| 7. | Na (me 100g$^{-1}$) | 2.27  | Very high |

Table 1. Soil analysis of Glapansari Experimental Station.
8. Ca (me.100 g⁻¹) 7.99 Intermediate
9. Mg (me.100 g⁻¹) 2.98 High
10. CEC (me.100 g⁻¹) 29.40 High

* Soil Chemical Assessment according to Eviati and Sulaiman (2012)

3.1. Effect of organic fertilizer and N fertilizer rates on tobacco growth components
There was no significant difference among treatments on plant height and leaf number of Kemloko tobacco at Temanggung, Central Java (Table 2). In this study, both organic fertilizer and N fertilizer rates did not have a significant effect on plant height and leaf number of Kemloko tobacco. Plant height ranges from 142 cm up to 148 cm, and leaf number ranges from 15 to 16.

Table 2. Effect of organic fertilizer and N fertilizer rates on plant height and leaf number of Kemloko tobacco.

| Organic Fertilizer | N Fertilizer (Kg ha⁻¹) | Plant height (cm) | Leaf number |
|--------------------|------------------------|-------------------|-------------|
| Manure             | 90                     | 142               | 16          |
|                    | 120                    | 144               | 15          |
|                    | 150                    | 146               | 16          |
| Vermicompost       | 90                     | 147               | 15          |
|                    | 120                    | 148               | 16          |
|                    | 150                    | 147               | 16          |
| LSD 5%             | ns *)                  | ns *)             |             |
| CV (%)             | 7.93                   | 4.33              |             |

*) Nonsignificant.

Interaction of organic fertilizer and N fertilizer rates did not significantly affect the leaf size of the bottom and the middle leaf of Kemloko tobacco (Table 3). The highest number of the bottom leaf was achieved by vermicompost treatment combined 150 kg/ha N, and the lowest value obtained by manure treatment combined by 90 kg/ha N. The highest number of the middle leaf was achieved by manure treatment combined 150 kg ha⁻¹ N, and the lowest value obtained by manure treatment combined by 90 kg ha⁻¹ N.

Interaction of organic fertilizer and N fertilizer rates did not have a significant effect on the leaf size of the top leaf of Kemloko tobacco. The leaf size of the top ranges from 787 cm² up to 940 cm², the lowest value of the leaf size of the top was obtained by manure+90 kg/ha N, which differs significantly from all other treatments.

Table 3. Effect of organic fertilizer and N fertilizer rates on leaf size of Kemloko tobacco.

| Organic Fertilizer | N Fertilizer (Kg/ha) | Length x wide of the leaf (cm²) |
|--------------------|----------------------|--------------------------------|
|                    |                      | Bottom leaf | Middle leaf | Top leaf  |
| Manure             | 90                   | 1055        | 1140        | 787 a     |
|                    | 120                  | 1144        | 1343        | 940 b     |
|                    | 150                  | 1098        | 1272        | 934 b     |
| Vermicompost       | 90                   | 1151        | 1201        | 919 b     |
|                    | 120                  | 1205        | 1182        | 893 b     |
|                    | 150                  | 1212        | 1197        | 933 b     |
| LSD 5%             | ns *)                | ns *)       |             |
| CV (%)             | 22.45                | 14.15       | 9.12        |

*) Nonsignificant
**) Numbers in the same column followed by the same letters are not significantly different at the 5% LSD test
3.2. Effect of organic fertilizer and N fertilizer rates on tobacco production components. 

The effect of treatments on tobacco production components is presented in Table 4. There was no significant effect among treatments on fresh yield and cured yield of Kemloko tobacco. The highest fresh yield and cured yield were achieved by vermicompost combined 120 kg/ha N treatment. The cured yield produced in this experiment (ranging from 784 to 883 kg/ha) generally exceeded the average produced by farmers.

### Table 4. Effect of organic fertilizer and N fertilizer rates on fresh yield and cured yield of Kemloko tobacco.

| Organic Fertilizer | N Fertilizer (Kg ha⁻¹) | Fresh yield (Kg ha⁻¹) | Cured yield (Kg ha⁻¹) |
|--------------------|------------------------|------------------------|------------------------|
| Manure             | 90                     | 5129                   | 784                    |
|                    | 120                    | 5384                   | 856                    |
|                    | 150                    | 4927                   | 814                    |
| Vermicompost       | 90                     | 5493                   | 848                    |
|                    | 120                    | 5533                   | 883                    |
|                    | 150                    | 5388                   | 833                    |
| LSD 5%             | ns *)                  | ns *)                  | ns *)                  |
| CV (%)             | 20.63                  | 13.51                  |                         |

*) Nonsignificant

3.3. Effect of organic fertilizer and N fertilizer rates on nicotine, sugar, and chlor content of tobacco. 

The effect of treatments on nicotine, sugar, and the chlorine content of tobacco are presented in Table 5. The nicotine content of tobacco ranges from 7.72 % up to 8.40%, and there was no significant effect among the treatments on nicotine content. The highest number of nicotine content was achieved by vermicompost combined 150 kg ha⁻¹ N treatment. Nicotine is a tobacco alkaloid compound synthesized in the roots with the main constituent element N, which is translocated to the leaves [13], so it is closely related to the magnitude of the element N, which is absorbed by tobacco.

The sugar content of tobacco ranges from 3.56 % up to 5.59%, and there was no significant effect among the treatments on sugar content. The highest sugar content was achieved by manure combined 120 kg ha⁻¹ N treatment.

### Table 5. Effect of organic fertilizer and N fertilizer rates on nicotine, sugar, and Cl content of Kemloko tobacco.

| Organic Fertilizer | N Fertilizer (Kg ha⁻¹) | Nicotine (%) | Sugar (%) | Chlor (%) |
|--------------------|------------------------|--------------|-----------|-----------|
| Manure             | 90                     | 7.92         | 3.56      | 0.68      |
|                    | 120                    | 7.72         | 5.59      | 0.70      |
|                    | 150                    | 8.28         | 3.96      | 0.84      |
| Vermicompost       | 90                     | 8.22         | 3.58      | 0.80      |
|                    | 120                    | 8.25         | 3.68      | 0.65      |
|                    | 150                    | 8.40         | 3.79      | 0.71      |
| LSD 5%             | ns *)                  | ns *)        | ns *)     |           |
| CV (%)             | 8.76                   | 32.39        | 33.29     |           |

*) Nonsignificant
The chlorine content of tobacco ranges from 0.65% up to 0.84%, and there was no significant effect among the treatments on the chlorine content. The highest number of chlorine content was achieved by manure combined 150 kg ha\(^{-1}\) N treatment. The Cl content produced in all treatments is below 1%, so it is still below the threshold. The responses of tobacco to chlorine are influenced by the tobacco type, variety, methods of fertilization, cultivation, and harvesting used. Irrigation water for tobacco should be at a level of Cl less than 40 mg l\(^{-1}\) [14].

3.4. Effect of organic fertilizer and N fertilizer rates on N and K uptake.

The effect of treatments on N and K uptake of tobacco is presented in Table 6. Nitrogen uptake of tobacco ranges from 58.00 kg ha\(^{-1}\) to 80.67 kg ha, and there was no significant effect among the treatments on N uptake. In general, N uptake in the vermicompost treatment was higher than in the manure treatment.

The highest N uptake was achieved by vermicompost combined 90 kg ha\(^{-1}\) N treatment. Nitrogen is an important component of nicotine so that it can affect the nicotine content of tobacco [13].

Potassium uptake of tobacco ranges from 42.33 kg ha\(^{-1}\) to 53.33 kg ha\(^{-1}\), and there was no significant effect among the treatments on K uptake. The highest K uptake was achieved by vermicompost combined 90 kg ha\(^{-1}\) N and manure combined 90 kg N treatment.

| Organic Fertilizer | N Fertilizer (kg ha\(^{-1}\)) | N (kg ha\(^{-1}\)) | K (kg ha\(^{-1}\)) |
|-------------------|---------------------------|-----------------|-----------------|
| Manure            | 90                        | 66.33           | 53.33           |
|                   | 120                       | 58.00           | 42.33           |
|                   | 150                       | 78.00           | 49.67           |
| Vermicompost      | 90                        | 80.67           | 53.33           |
|                   | 120                       | 70.67           | 44.33           |
|                   | 150                       | 60.67           | 44.67           |
| LSD 5%            |                           | ns\(^{-1}\)     | ns\(^{-1}\)     |
| CV (%)            | 36.40                     | 34.31           |                 |

*) Nonsignificant

3.5. Effect of organic fertilizer and N fertilizer rates on grade index and crops index of tobacco.

The effect of treatments on grade index and crops index of tobacco were presented in Table 6. The graded index of tobacco ranges from 76.00 up to 79.67, and there was no significant effect among the treatments on grade index. The highest grade index was achieved by vermicompost combined 90 kg ha\(^{-1}\) N treatment. The crop index of tobacco ranges from 60.00 up to 70.67, and there was no significant effect among the treatments on grade index. The highest grade index was achieved by vermicompost combined 90 kg ha\(^{-1}\) N treatment, as well as in the observation of crop index.

| Organic Fertilizer | N Fertilizer Kg ha\(^{-1}\) | Grade Index | Crop Index |
|-------------------|---------------------------|-------------|------------|
| Manure            | 90                        | 76.67       | 60.00      |
|                   | 120                       | 79.33       | 67.67      |
|                   | 150                       | 76.00       | 62.00      |
| Vermicompost      | 90                        | 79.67       | 70.67      |
|                   | 120                       | 78.00       | 68.33      |
4. Conclusion
In general, tobacco plants grew normally either with manure or vermicompost. There was no significant difference between all the treatments in the observation of growth and production. This shows that vermicompost can be recommended as a tobacco fertilizer to substitute manure. Vermicompost can reduce N fertilizer input and could be an ameliorant of tobacco dryland. It is important to further study to see the effect of vermicompost on soil microbial populations.

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