Nutrients balance under organic rice farming system in Central Java, Indonesia

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Abstract. Understanding and calculation the net nutrient balance in an organic rice farming system is crucial to determine its ability to maintain soil fertility in the long term. The objective of this study is to calculate simple nutrient balances of nitrogen (N), phosphorus (P), and potassium (K) under different sources of organic fertilizer in organic rice farming. The results indicated an imbalance between nutrients, a general surplus for P budget +0.8 to +43.5 kg ha\(^{-1}\) season\(^{-1}\) and deficit for N budgets from -49.2 to +38.5 kg ha\(^{-1}\) season\(^{-1}\); and K -56.8 to +38.6 kg ha\(^{-1}\) season\(^{-1}\). The application of 5t ha\(^{-1}\) of chicken manure combined with 500 kg ha\(^{-1}\) of azolla and 2 t ha\(^{-1}\) of straw compost gave better growth, yield and positive N, P, K balance for local rice variety Mentik Wangi.

1. Introduction
In organic agriculture, the maintenance and enhancement of soil fertility is essential for long-term cultivation to support good quality and yield production, preserve sustainability of soil, minimize environmental impact, and improve soil organic matter content, floral and faunal diversity, and biological activity, higher richness and abundance of organism [1, 2]. In the same time, it provides a number of important environmental and social services, such as preserving and improving soil quality, increasing carbon sink, minimizing water use, preserving biodiversity, halting the use of harmful chemicals, thereby guaranteeing healthy food to consumers [3]; greatly reduces soil loss and creates higher water holding capacity [2], and conserves global biodiversity and associated ecosystem services [4]. Organic agriculture also demonstrates greater energy efficiency and reduced greenhouse gas (GHG) emissions per land unit and unit of production compared with conventional farming attributable to the absence of synthetic fertilizers, particularly nitrogen, and synthetic pesticides. Organic systems appear to have greater carbon sequestration potential [5]. Furthermore, Gomiero et al. [2] stated that organically managed soils had advantages over conventionally managed soils, i.e. they produced larger yields compared to conventional farming under conditions of water scarcity. More importantly, organic agriculture has higher energy efficiency (input/output).

The nutrient management in organic farming is very crucial through introducing biological nitrogen fixation (BNF), nutrient cycling within the farm and other natural resources and organic waste streams [6, 7, 8]. Since chemical fertilizers are not allowed in organic farming [2], nutrients for crop production are mostly fulfilled by organic fertilizer from compost containing different organic materials from local resources, whose nutrients are made available to crops through the action of soil micro-organisms and bacteria [9]. A review conducted by Patrick et al. [10] in Canada and United States indicate that (a) combination between cover/green manure crops and manure are common sources mainly for plant
available N, (b) soil nutrient deficiencies can develop through sole reliance on cover/green manure crops; (iii) dependence on animal manure can lead to N and P excesses. In the long-term, it can be sustainable enough of nutrient are returned to match or balance removal and losses from inputs and outputs. On one hand, there is a risk of environmental pollution, through losses of nutrients via leaching or runoff when inputs greater than outputs and soil fertility depletion if the opposite sites [11].

Nitrogen (N) is one of the critical elements in soil and typically become the limiting element for plant productivity, where a balance the amount of N is the key. Organic input of N would come from crops residues (straw, stalk and leaf), green manure (sesbania, tithonia) and manure compost [9]. Phosphorus (P) fertilization in organic farming depends on organic P input sources such as animal manure, composts or their natural sources such as rock phosphates, and on other biological and biochemical process of organic-P [12]. Higher microbial and enzymatic activities have been repeatedly observed in organically cultivated soils compared to conventionally cropped soils [13].

Determining fertilizer and manure application rate in organic farming system is usually calculated from the optimal N rate instead of nutrient K requirements. As a result, there can be an excess or lack of K depending on the crop and rotation. In many organic farming systems, especially in areas dominated by coarse-textured or organic soils, the lack of K will occur. Otherwise in areas dominated by young, clay-rich soils can be potentially having enough supply of K for crops growth. In organic farming systems, potassium (K) deficiency may become a significant problem due to nutrient import restrictions [14, 15].

In Indonesia, the organic farming movement was initiated and developed since early 1990 for organic vegetables farming and early 2000 for organic rice [16]. Local sources of organic fertilizer in farms mainly from barnyard manure and urine (from goat, horse, cow, chicken), green manure, crop residues, hedgerow clipping, Azolla pinata, blue green algae, Sesbania rostrata [7, 17]. Organic manure is an important soil amendment, as well as a source of nutrients for organic farming system. When high yields are expected in organic farming system, organic manure which have low nutrient contents and specific nutrient release characteristics should be managed carefully. More biomass per unit area at higher yields needs and removes more nutrients [9]. The information about nutrients balanced under rice organic farming in Indonesia is still limited now.

Nutrient demands of high yielding rice varieties (VUBs) that dominated more than 70% of Indonesia's rice cultivation area generally need more macro-N, P, and K than local varieties. To produce about 6 t ha⁻¹ of rice grain in conventional practices it needs 90 kg N, 15.6 kg P, and 87 kg K [18]. However, important strategies are needed to select adequate quantity of nutrients for increasing organic rice yield [19] since organic rice only relies on organic fertilizer as a source of nutrients for its growth and to improve soil chemical, physical and biological properties. Therefore, the quality of organic fertilizer especially C:N ratio is very important in the selection of given fertilizer because it would affect the availability of nutrients for crop growth.

Nutrient budget is a valid tool to investigate the nutrient demand or surplus of a system [20, 21] and to determine its ability to maintain soil fertility in the long-term. The calculation of nutrient balance for all nutrients in organic agriculture is difficult because the nutrients come from a variety of organic materials. Therefore, as an initial stage, only nutrient balance measurements are made for the main macro elements N, P and K. Furthermore, Le Clech [20] found that the nutrient balance is closely related to the production system. Negative balances indicate greater exports than imports. If nutrient inputs to a farm exceed nutrient outputs, then some nutrients are not utilized, which may have adverse environmental impacts (positive balance) [21].

The purpose of this research is to evaluate the effects of organic matter application on N, P and K balances through five consecutive growing period of organic rice in Sukorejo Village, Sragen, Central Java.
2. Materials and methods

This experiment was conducted on organic lowland rice areas which located at Dukuh Pondok, Sukorejo Village, Kec. Sambirejo, Kab. Sragen in the slopes of Mount Lawu (70 31’ 6.2” South Latitude and 1110 8’ 45.1” West Longitude), with elevation height of 340 m above sea level (asl) on an Inceptisols.

The experiments were conducted in a randomized block design with three replications during five consecutive seasons between 2008 to 2009. The treatments was set up as the following: T1 = goat manure 5 t ha⁻¹ + Azolla 500 kg ha⁻¹, T2 = cattle manure 5 t ha⁻¹ + Azolla 500 kg ha⁻¹, T3 = chicken manure 5 t ha⁻¹ + Azolla 500 kg ha⁻¹, T4 = goat manure 5 t ha⁻¹ + rice straw compost 2 t ha⁻¹, T5 = cattle manure 5 t ha⁻¹ + rice straw compost 2 t ha⁻¹; T7= goat manure 5 t ha⁻¹ + charcoal 300 kg ha⁻¹; T8 = cattle manure 5 t ha⁻¹ + charcoal 300 kg ha⁻¹ and T9 = chicken manure 5 t ha⁻¹ + charcoal 300 kg ha⁻¹ and T10 = cattle 5 t ha⁻¹ as a farmer practices.

All of the organic fertilizer was applied in soil a week before rice transplanting. Local rice variety Mentik Wangi was transplanted with row spacing 20 cm x 20 cm at 21 days after sowing 2 plants per hole. For the 2009 experiment the charcoal was replaced by Azolla pinnata and Tithonia diversifolia as a green manure. Azolla is promising sources for N in lowland organic rice, it given in the form of fresh and incorporated into the soil, while tithonia in the form of compost. The composting was conducted in a shelter, each organic material was layered 100 cm thick on the dry soil surface in the shelter then moist by spraying with a decomposer of each 25cm. After 2-3 weeks, the compost was incorporate into the rice field.

Observation was conducted to the nutrient content of organic fertilizer, irrigation water, crop yield and nutrient uptake from edible part and plant residue (biomass). Nutrient output (loss) originates determined from total harvested offtakes (rice grain and straw) multiplied by nutrient content. Nutrient input (gain) is derived from added nutrient contents of organic fertilizer and irrigated water. Based on this formula [20], nutrient budget for N, P and K (kg ha⁻¹ season⁻¹) at Sukorejo, Sragen, was calculated by subtracting nutrient input to nutrients output for each consecutive cropping season during 2008 to 2009. Visualizations and calculations were performed using Microsoft Excel.

3. Results and discussion

3.1. Soil properties

The result of initial soil chemical properties analysis from experiment site indicated that the soil was silty clay loam textured (clay=35%, silt=54%, sand=11%) with a slightly acidic soil reaction (pH=5.8). The C-organic content (1.73%), N-total (0.18%) and C/N ratios (10) were low. The P-HCl 25% extract was high (98.3 mg 100 g⁻¹) and K-potential was low (10.3 mg 100 g⁻¹). P-Bray extract was very high (69 ppm). Exchanged Ca as moderate (10.19 cmol(+), kg⁻¹), exchangeable Mg as quite high (2.96 cmol(+), kg⁻¹), exchangeable K as very low (0.04 cmol(+), kg⁻¹), and exchangeable Na as very low (0.21 cmol(+), kg⁻¹). Cation exchange capacity was moderate (17.19 cmol(+), kg⁻¹) and base saturation was high (78%). The heavy metal content of Pb and Cd was well below the ground quality standard threshold (1.93 ppm and 0.13 ppm). The micro nutrients of Fe, Cu, Zn, Mn were low (respectively 107 ppm, 3 ppm, 1.33 ppm and 137 ppm). In general, Inceptisols in Sragen has a good soil fertility level with clay texture and high P potential and availability, high CEC and base saturation content.

3.2. Nutrient content of organic fertilizer

Nutrient content of used organic fertilizer varied depends on the sources. Chicken manure excelled other organic sources in terms of N, P, K contents. P content in chicken manure was highest (3.71%) following by goat manure (1.45%) and tithonia compost (1.20%). The green manure contained highest N, Azolla is the highest (3.60%) followed by rice straw, Tithonia and manure (chicken>goat> cattle) (table 1). Rice straw is the main sources of organic material in lowland rice areas with high content of K (5.89%) and N (1.75%). However, to fulfill the nutrient requirement of organic rice crops, additional nutrient sources should be combined. The similar results were reported by Fahmuddin [9], which chicken manure was
the highest N, P, K content and tithonia was superior for N and P content. Under application of 5 t ha\(^{-1}\) of chicken manure will contain 46 kg of N, 38 kg of P and 48 kg of K.

**Table 1.** Average nutrient content of different sources of organic material for the experiment.

| Treatment            | N-organic (%) | C-organic (%) | C/N | Macro nutrients (%) |
|----------------------|---------------|---------------|-----|---------------------|
|                      |               |               |     | P      | K      | Ca    | Mg    |
| Goat manure          | 1.31          | 18.54         | 14  | 1.45   | 1.00   | 1.39  | 0.38  |
| Cattle manure        | 0.83          | 13.01         | 16  | 0.78   | 0.04   | 1.12  | 0.21  |
| Chicken manure       | 1.85          | 28.04         | 15  | 3.71   | 2.51   | 3.84  | 0.13  |
| Straw compost        | 1.75          | 19.31         | 11  | 0.54   | 5.89   | 0.75  | 0.28  |
| Tithonia compost     | 1.46          | 15.75         | 11  | 1.20   | 1.82   | 1.35  | 0.41  |
| Rice husk charcoal   | 0.66          | 3.93          | 6.0 | 0.17   | 0.42   | 0.11  | 0.17  |
| Azolla               | 3.60          | 37.89         | 10.5| 0.58   | 1.97   | 2.21  | 0.41  |

3.3. Rice yield
During five cropping seasons of organic rice, rice yields was fluctuated depend on the climate condition, pests and plant diseases such as planthopper, blast and rats. Rice yield on the first and second season was the highest and become decreased at the following season (table 2).

Table 2 shows that different combination sources of organic fertilizer have no significant difference in grain yield compare to farmer’s practices (T10=cattle manure 5 t ha\(^{-1}\)). During five consecutive rice planting seasons, the first and second season show the highest rice yield (grain yield at harvest) 9.00 to 10.17 kg ha\(^{-1}\). There is no significant difference between the treatments and farmer’s practices. At the third planting season, rice yield was decreased 6.17 to 6.73 t ha\(^{-1}\) and the next season increased 6.85 to 7.69 t ha\(^{-1}\) at fourth and fifth planting seasons. The highest yield was achieved at treatment T6, T9, T2, T6, T6 from seasons 1 to 5. Treatment T6 is combination chicken manure 5 t ha\(^{-1}\) and rice straw compost 2 t ha\(^{-1}\). The high yield on first season it due to the favorable climate condition, water irrigation and compost quality.

**Table 2.** Average of organic rice yield during five plating seasons at Sukorejo, Sragen.

| Treatments | 1         | 2         | 3         | 4         | 5         |
|------------|-----------|-----------|-----------|-----------|-----------|
| T1         | 9.91 ab   | 9.37 bc   | 6.50 a    | 7.74 a    | 7.31 ab   |
| T2         | 9.66 abc  | 9.83 ab   | 6.73 a    | 7.48 a    | 7.69 a    |
| T3         | 9.94 ab   | 9.46 bc   | 6.60 a    | 7.36 a    | 7.50 ab   |
| T4         | 9.31 abc  | 9.00 c    | 6.50 a    | 7.31 a    | 6.85 b    |
| T5         | 9.28 abc  | 9.24 bc   | 6.20 a    | 7.23 a    | 7.69 a    |
| T6         | 10.04 a   | 9.83 ab   | 6.70 a    | 7.60 a    | 7.69 a    |
| T7         | 9.09 c    | 9.47 bc   | 6.33 a    | 7.54 a    | 7.22 ab   |
| T8         | 9.47 abc  | 9.50 b    | 6.17 a    | 7.63 a    | 7.22 ab   |
| T9         | 9.63 abc  | 10.17 a   | 6.53 a    | 7.52 a    | 7.22 ab   |
| T10        | 9.15 bc   | 9.03 c    | 6.47 a    | 7.55 a    | 7.41 ab   |
| CV (%)     | 14.72     | 14.15     | 12.19     | 14.28     | 15.75     |

Numbers in the same column with different letters are significantly different at the 0.05 probability level using the Duncan Multiple Range Test (DMRT).

Although the grain yield is not significantly different, based on the calculation of the balance of N, P, K nutrients table 2), it will be clear that the application of unsuitable sources of fertilizer input such
as manure without additional nutrients sources (Azolla, straw compost, charcoal) will result in nutrient depletion (negative balances) from the soil.

3.4. Nutrients balance

The nutrient balance from organic rice in Sragen which are fertilized by three types of barnyard manure (chicken, goat, cow) in combined with azolla, straw compost, rice husk charcoal, tithonia compost was presented in table 3 and figure 1. The data show positive balance of P for all treatments and have a negative balance of N and K at most of the treatments. Variation in N budgets from -49.2 to +38.5 kg ha\(^{-1}\) season\(^{-1}\); P budget +0.8 to +43.5 kg ha\(^{-1}\) season\(^{-1}\) and for K -6.8 to +38.6 kg ha\(^{-1}\) season\(^{-1}\). Application of barnyard manure from goat, cattle and chicken combined with Azolla or rice husk charcoal without straw compost give a negative balance for N and K. Between the barnyard manure, chicken manure has the highest content of N, P, K follow by cattle and goat. Rice straw contributes quite a lot of nutrients. especially potassium and nitrogen when combined with chicken manure provides a positive K nutrient balance.

The rice straw from the experiments contained K about 6 to 8 times higher than the grain (1.44 to 1.83% in straw and 0.30 to 0.48% in grain). Conversely, N and P nutrients content in grain (1.08 to 1.24% N; 0.27 to 0.32% P) are about 2 to 3 times higher than that on straw (0.48 to 0.74%). The amount of potassium allocated in the rice straw makes the growth or vigor of the rice plant stronger so it is not easy to fall, while the N and P nutrients are allocated in the grain part (rice grain) as the protein constituent. Because rice straw is not included in the consume part, the rest of this harvest can be utilized as one of the best sources of organic fertilizer as a source of K for rice plants [22]. Long-term research conducted by Adiningsih [22] showed that the return of 5 kg ha\(^{-1}\) of rice straw compost to paddy fields could replace the KCl equivalent of 50 kg KCl ha\(^{-1}\). Therefore, in the cultivation of organic rice, rice straw is necessary as a source of K plant nutrients.

**Tabel 3.** Balance of N, P and K under rice organic farming at 1 to 5 cropping seasons in Sragen, Central Java.

| Code | Input (kg ha\(^{-1}\))          | Output (kg ha\(^{-1}\)) | Balance (kg ha\(^{-1}\)) |
|------|--------------------------------|-------------------------|--------------------------|
|      | N    | P    | K    | N    | P    | K    | N    | P    | K    |
| Season-1 |
| T1  | 34.0 | 16.2 | 27.9 | 57.6 | 15.4 | 70.8 | -23.6 | 0.8  | -42.9 |
| T2  | 22.4 | 20.4 | 24.7 | 71.6 | 12.1 | 54.9 | -49.2 | 8.3  | -30.2 |
| T3  | 51.5 | 44.6 | 54.4 | 68.2 | 11.9 | 73.1 | -16.7 | 32.7 | -18.7 |
| T4  | 61.3 | 19.9 | 75.4 | 56.4 | 12.5 | 63.8 | 4.9   | 7.4  | 11.6  |
| T5  | 49.8 | 24.1 | 72.2 | 63.9 | 10.2 | 70.6 | -14.1 | 13.9 | 1.6  |
| T6  | 78.9 | 48.2 | 101.8 | 68.8 | 11.2 | 63.2 | 10.1 | 37.0 | 38.6  |
| T7  | 41.7 | 17.2 | 33.3 | 59.5 | 11.6 | 56.7 | -17.8 | 5.6  | -23.4 |
| T8  | 30.1 | 21.5 | 30.1 | 55.4 | 10.9 | 58.3 | -25.3 | 10.6 | -28.2 |
| T9  | 59.2 | 45.6 | 59.7 | 67.8 | 11.0 | 53.4 | -8.6  | 34.6 | 6.3  |
| T10 | 21.8 | 20.4 | 23.1 | 58.1 | 9.9  | 42.7 | -36.3 | 10.5 | -19.6 |
| Season-2 |
| T1  | 44.0 | 20.6 | 40.4 | 43.8 | 11.3 | 80.7 | 0.1   | 9.3  | -40.2 |
| T2  | 31.6 | 26.7 | 37.3 | 54.9 | 9.3  | 57.3 | -23.3 | 17.4 | -20.0 |
| T3  | 58.8 | 50.5 | 66.8 | 45.7 | 8.0  | 73.3 | 13.1  | 42.5 | -6.5  |
| T4  | 67.9 | 23.9 | 80.3 | 39.4 | 8.7  | 71.5 | 28.5  | 15.1 | 8.8   |
| T5  | 55.5 | 30.0 | 77.1 | 43.9 | 7.0  | 56.6 | 11.6  | 23.0 | 20.6  |
| T6  | 82.8 | 53.8 | 106.7 | 50.6 | 8.2 | 80.9 | 32.2  | 45.6 | 25.7  |
| T7  | 49.5 | 21.3 | 40.1 | 43.4 | 8.5  | 52.2 | 6.1   | 12.8 | -12.1 |
| T8  | 37.1 | 27.5 | 36.9 | 39.3 | 7.8  | 53.8 | -2.1  | 19.7 | -16.8 |
| T9  | 64.3 | 51.3 | 66.5 | 57.5 | 9.2  | 75.1 | 6.8   | 42.1 | -8.7  |
| T10 | 28.9 | 26.4 | 29.9 | 43.6 | 7.4  | 86.7 | -14.7 | 19.0 | -56.8 |
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| Code | Input (kg ha\(^{-1}\)) | Output (kg ha\(^{-1}\)) | Balance (kg ha\(^{-1}\)) |
|------|------------------------|-------------------------|------------------------|
|      | N  | P | K   | N  | P | K   | N  | P | K |
| Season-3 |     |   |     |     |   |     |     |   |   |
| T1   | 54.8 | 23.2 | 43.4 | 37.8 | 10.1 | 59.1 | 17.0 | 13.2 | -15.8 |
| T2   | 39.4 | 28.3 | 38.0 | 50.4 | 8.5  | 48.7 | -11.0 | 19.8 | -10.8 |
| T3   | 64.0 | 49.6 | 64.7 | 43.0 | 7.5  | 64.0 | 21.0 | 42.1 | 0.7 |
| T4   | 62.5 | 24.5 | 66.8 | 39.0 | 8.7  | 67.4 | 23.5 | 15.8 | -0.5 |
| T5   | 47.1 | 29.5 | 61.5 | 41.7 | 6.6  | 54.7 | 5.4  | 22.9 | 6.8 |
| T6   | 71.6 | 50.9 | 88.2 | 45.4 | 7.4  | 65.1 | 26.2 | 43.5 | 23.1 |
| T7   | 48.0 | 22.5 | 43.1 | 42.6 | 8.3  | 54.8 | 5.4  | 14.2 | -11.7 |
| T8   | 32.6 | 27.5 | 37.7 | 37.7 | 7.4  | 57.5 | -5.1 | 20.2 | -19.8 |
| T9   | 57.1 | 48.9 | 64.5 | 47.4 | 7.7  | 54.6 | 9.7  | 41.2 | 9.8 |
| T10  | 29.8 | 27.2 | 30.8 | 40.6 | 6.9  | 68.8 | -10.9 | 20.2 | -38.0 |
| Season-4 |     |   |     |     |   |     |     |   |   |
| T1   | 36.3 | 15.9 | 38.8 | 40.9 | 10.2 | 45.1 | -4.6  | 5.6  | -6.2 |
| T2   | 24.8 | 20.4 | 30.5 | 39.6 | 9.2  | 36.8 | -14.9 | 11.2 | -6.4 |
| T3   | 49.2 | 38.5 | 55.3 | 47.2 | 10.7 | 37.6 | 2.0  | 27.8 | 17.7 |
| T4   | 50.3 | 17.8 | 62.1 | 39.6 | 8.6  | 42.3 | 10.7 | 9.2  | 19.7 |
| T5   | 38.8 | 22.2 | 53.7 | 38.7 | 8.1  | 37.0 | 0.1  | 14.2 | 16.7 |
| T6   | 63.2 | 40.4 | 78.5 | 43.4 | 9.8  | 43.3 | 19.8 | 30.6 | 35.2 |
| T7   | 48.0 | 20.4 | 50.9 | 40.6 | 8.7  | 39.7 | 7.4  | 11.7 | 11.2 |
| T8   | 36.4 | 24.9 | 42.5 | 42.0 | 8.5  | 44.2 | -5.6 | 16.4 | -1.7 |
| T9   | 60.9 | 43.0 | 67.4 | 38.8 | 8.4  | 32.8 | 22.1 | 34.7 | 34.6 |
| T10  | 21.8 | 20.0 | 23.1 | 41.7 | 8.9  | 51.1 | -19.9 | 11.1 | -28.0 |
| Season-5 |     |   |     |     |   |     |     |   |   |
| T1   | 44.4 | 15.7 | 45.2 | 31.0 | 7.4  | 40.9 | 13.4 | 8.3  | 4.2 |
| T2   | 38.0 | 21.2 | 31.3 | 34.2 | 7.4  | 39.6 | 3.8  | 13.8 | -8.3 |
| T3   | 63.7 | 36.2 | 51.8 | 43.3 | 9.2  | 46.0 | 20.3 | 27.0 | 5.7 |
| T4   | 58.4 | 17.9 | 68.4 | 32.1 | 6.3  | 45.9 | 26.3 | 11.6 | 22.5 |
| T5   | 52.0 | 23.4 | 54.6 | 35.0 | 6.7  | 43.5 | 17.0 | 16.7 | 11.0 |
| T6   | 77.7 | 38.5 | 75.0 | 39.1 | 8.0  | 53.9 | 38.5 | 30.5 | 21.1 |
| T7   | 65.0 | 19.2 | 57.3 | 33.1 | 6.7  | 44.0 | 31.9 | 12.5 | 13.2 |
| T8   | 58.6 | 24.7 | 43.4 | 35.0 | 6.6  | 54.9 | 23.6 | 18.1 | -11.5 |
| T9   | 84.2 | 39.7 | 63.8 | 33.0 | 6.6  | 37.6 | 51.2 | 33.2 | 26.3 |
| T10  | 23.6 | 20.0 | 24.0 | 37.2 | 7.3  | 63.7 | -13.6 | 12.7 | -39.8 |

Notes: T1=goat manure 5 t ha\(^{-1}\) + Azolla 500 t ha\(^{-1}\), T2=cattle manure 5 t ha\(^{-1}\) + Azolla 500 t ha\(^{-1}\), T3=chicken manure 5 t ha\(^{-1}\) + Azolla 500 t ha\(^{-1}\), T4=goat manure 5 t ha\(^{-1}\) + rice straw compost 2 t ha\(^{-1}\), T5=cattle manure 5 t ha\(^{-1}\) + rice straw compost 2 t ha\(^{-1}\), T6=chicken manure 5 t ha\(^{-1}\) + rice straw compost 2 t ha\(^{-1}\), T7=goat manure 5 t ha\(^{-1}\) + charcoal 300 kg ha\(^{-1}\), T8=cattle manure 5 t ha\(^{-1}\) + charcoal 300 kg ha\(^{-1}\) and T9=chicken manure 5 t ha\(^{-1}\) + charcoal 300 kg ha\(^{-1}\) and T10=cattle 5 t ha\(^{-1}\) as a farmer practices.

Tagmann et al. [23] presented opposite evidence from a long-term study over 21 years to access the long-term effect of organic and conventional farming on total and available P indicated that after 21 years, the average P input by fertilizers was lower than P output by harvested products in organic farming (-21 kg P ha\(^{-1}\) y\(^{-1}\)). McRae et al. [6] reported under horticulture organic farms that all the nitrogen (N) budgets showed an N surplus (average 83.2 kg N ha\(^{-1}\) y\(^{-1}\)), surplus for P (average 3.6 kg P ha\(^{-1}\) y\(^{-1}\)) and deficit for K budgets (-14.2 kg K ha\(^{-1}\) y\(^{-1}\)) showing large surpluses resulting from purchased manure.
Notes: T1=goat manure 5 t ha\(^{-1}\) + Azolla 500 t ha\(^{-1}\), T2=cattle manure 5 t ha\(^{-1}\) + Azolla 500 t ha\(^{-1}\), T3=chicken manure 5 t ha\(^{-1}\) + Azolla 500 t ha\(^{-1}\), T4=goat manure 5 t ha\(^{-1}\) + rice straw compost 2 t ha\(^{-1}\), T5=cattle manure 5 t ha\(^{-1}\) + rice straw compost 2 t ha\(^{-1}\), T6=chicken manure 5 t ha\(^{-1}\) + rice straw compost 2 t ha\(^{-1}\), T7=goat manure 5 t ha\(^{-1}\) + charcoal 300 kg ha\(^{-1}\); T8=cattle manure 5 t ha\(^{-1}\) + charcoal 300 kg ha\(^{-1}\) and T9=chicken manure 5 t ha\(^{-1}\) + charcoal 300 kg ha\(^{-1}\) and T10= cattle 5 t ha\(^{-1}\) as a farmer practices.

CS1=cropping season1, etc.

**Figure 1.** Cumulative N, P, K balance under five consecutive season of rice organic farming system under different sources of organic fertilizer at Sragen, Central Java.

Negative balance of N and K meant that N and K from given fertilizer are insufficient to meet the needs of nutrients N and K of rice crops, so the plants take nutrient reserves from the soil. Gaseous nitrogen losses during manure management and gaseous as well as leaching nitrogen losses after
application are major reasons for such nutrient imbalances [24]. If this happens continuously, there will be a great N and K nutrient depletion from the soil. In soil rich with K reserves soils, this phenomenon is still possible. However, if it occurs in K-poor soil and land reserves, then the growth of rice crops will be disturbed due to K deficiency. Deficit of K on organic crops in greenhouse farms also reported by Zikeli et al. [25]. Conversely for N, P and S was surplus. Another study reported by Reimer et al. [21] shows from 36 individual organic farms in Europe suggested an imbalance between nutrients, a general surplus was count for N, Mg and S, a balance for P budget and a deficit for K. Andrist-Rangel et al. [26] also reported that annual K balanced for 18 years in the organic farming system was -22 to -77 kg K ha$^{-1}$ year$^{-1}$.

Based on the field trials, it can be concluded that among the different types of applied manure, chicken poultry give the largest contribution of nutrients followed by cattle and goats. Chicken manure itself without addition of azolla, rice straw compost, charcoal would give negative balance for N and K. Judging from the balance sheets, the input from the manure is still insufficient; therefore, straw compost and charcoal from rice husk must be added to increase the K source. The recommended dose is 5 t ha$^{-1}$ chicken manure and 2 t ha$^{-1}$ of compost rice straw.

The results in figure 1 shows that partial and cumulative balance for N and K were mostly negative, except for treatment chicken manure combined with azolla and straw compost. The positive balance for N and K was achieved at treatment manure integrated with azolla and straw compost. Conversely, balance of P was positive in all of the treatment combinations. Chicken manure was the best input sources for rice organic farming, follow by cattle and goat manure. This result indicates that under organic rice, N and K should be maintained carefully by applying potential N and K sources such as azolla, sesbania, straw and other green manure. Similar results were showed from evaluation for nine organic farms in the UK. There is only system with crops rotations with large returns of manure showed a K surplus or a balanced K budget [27]. In the future, application of commercial natural organic fertilizer with relative high nutrients concentration such as N, P, K to adjust nutrient supply to crop requirement should be consider, such as feather meal, horn meal, vinasse, meat and bone meal [24].

4. Conclusions
The balance of N, P and K in the soil we consider that: (1) N and K mostly gave negative balance for selected treatment, (2) P shows positive balance for all the treatment, (3) the application of chicken manure 5 t ha$^{-1}$ combined with azolla 500 kg ha$^{-1}$ and straw compost 2 t ha$^{-1}$ gave better growth, yield and positive N, P, K balance for local rice variety Mentik Wangi in Sukorejo, Sragen.

Nutrient management which includes the selection of types of organic fertilizers, selection of good quality of organic material for organic fertilizers, determined the correct dosage of fertilizers and the selection of suitable plant varieties are important things that must be considered. Nutrient gain and nutrient loss should be managed in a proper amount. The combination of crop and the type of organic fertilizer should be selected to avoid nutrient imbalance. The key challenge is to design cropping systems with a higher share of N inputs via biological N$_2$ fixation.

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