Improvement of plant growth and production of sweet corn with organic-N and nature-P enriched manure and inorganic fertilizer in Batang District of Central Java Indonesia

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Abstract. Crop productivity is affected by organic and inorganic fertilizer. Sweet corn (Zea mays saccharatta) is used under crop-livestock system (CLS) in Indonesia. The characteristic of CLS is crop yield for food, stover and cornhusk for livestock feed, and dung (i.e. cattle, goat, poultry) for manure as organic fertilizer. Organic-N (Leucaena leucocephala) and nature-P (rock phosphate) enhanced the quality of manure if added at the initial fermentation process that was called manure plus. Present study investigated the effect of organic-N and nature-P enriched manure application on plant growth and sweet corn production, stover and cornhusk production in Batang District of Central Java. The experiment was conducted using a randomized complete block design with seven treatments and four replicates, T1 (SA+TSP), T2 (cattle manure+inorganic), T3 (cattle manure plus), T4 (goat manure+inorganic), T5 (goat manure plus), T6 (poultry manure+inorganic), T7 (poultry manure plus). The results showed that plant height and sweet corn production, stover and cornhusk production significantly affected by the treatment. Goat manure plus resulted in similar on plant growth and sweet corn production compared to manure+inorganic fertilizer. It was concluded that N-Leucaena leucocephala and P-RP enriched manure replaces inorganic fertilizer (SA+TSP).

1. Introduction
Sweet corn (Zea mays saccharatta) is also called sugar corn and pole corn. It is variety of maize with sugar content greater than 25% during the milking stage [1] with milky and sweet grain [2]. Sweet corn is grown by farmer under crop-livestock system (CLS) in Indonesia. The characteristic of CLS is crop yield for food and stover for ruminant feed, being the manure used as organic fertilizer which important to maintain the fertility of cultivated soils [3]. Recent research in various regions of the world has indicate that integrated crop-livestock system can enhance sustained crop and livestock production by efficiently using agriculture system resources [4].

Sweet corn can be harvested in 70-75 days after planting and both of cornhusk and stover have moisture content between70-80% and can be used for ruminant feed [2, 5]. However, most of the soil in Indonesia that cultivated for crop production is deficient in phosphor (P) and nitrogen (N), which can be corrected by applying inorganic fertilizer of P and N fertilizer such as TSP and ZA, respectively. The high cost of inorganic fertilizer has caused farmers to focus their attention back to nature on manure, nature-P (rock phosphate) and organic-N (N-Gliricidia sepium). Manure in general is low in most of major nutrients, and manure quality can be improved by enrichment utilizing nature-P and organic-N such as P-rock phosphate (P-RP) and N-Gliricidia sepium, respectively [6, 7]. Rock phosphate enriched
manure could be an effective strategy for obtaining maximum maize yield with low cost input, in addition to improve soil fertility [8].

Main problem in using the nature-P and N-Gliricidia sepium are to solubilize an enhance availability of P and content [9, 10]. However, if nature-P and legume-N is allowed to react with organic acids resulted during fermentation, a major part of nature-P and N-Gliricidia sepium could be solubilized for plant uptake [1, 5, 10]. Application of organic fertilizers with the added of inorganic fertilizers, increased soil fertility and crop production also save the use of inorganic fertilizers [5, 11]. This is inline with the Regulation of the Minister of Agriculture No.40/2007 that the purpose of organic material returned or the provision of organic fertilizers equipped with inorganic fertilizers is to improve soil condition and fertility. Organic manure from different sources application enhanced soil porosity, soil moisture contents and water holding capacity while reduces soil compaction and bulk density [12]. The overall of principal components analysis of soil fertility showed that manure fertilization was the best management strategy in cropland soil [13]. Field experiment of organic fertilizer resulted that responses were highest after the third crop harvest suggesting that mineralization or organic-N and nature-P increased with time [14]. Furthermore, there is also a need for comparing different types of livestock manures under similar field conditions. This is important in coming up with indications on manures recommendations. Organic fertilizer builds on the principles of improving soil fertility through incorporation of legumes and compost materials [15]. The current study therefore carried out to evaluate of cattle, goat, and poultry manure combined with inorganic fertilizer or as manure plus (N-Leucaena leucocephala and P-RP enriched manure) on plant growth and sweet corn production in Batang District of Central Java.

2. Materials and Methods

2.1. Organic-N and nature-P enriched manure and inorganic fertilizers as treatment

The materials used were manure of cattle, goat, and poultry collected from local farmer, nature-P (rock phosphate) collected from the community of mining in Pati District of Central Java. *Leucaena leucocephala* as organic-N collected from village in Batang District of Central Java. Sweet corn seed were purchased from nursery shop. Manure organic fertilizer (20 t ha\(^{-1}\)) made from dung of cattle, goat, and poultry, respectively. It was inoculated with decomposer (EM4) and added molasses. The material for manure plus was made from mixture of nature-P (P-rock phosphate) (66 kg P ha\(^{-1}\)), organic-N was N-Leucaena leucocephala (200 kg N ha\(^{-1}\)), and 20 t ha\(^{-1}\) dung of cattle, goat, and poultry, respectively. Nature-P and N-legume enriched manure of cattle, goat, and poultry, respectively, were inoculated with EM4 and added molasses as well. Manures and manures plus then composted anaerobically for 8 weeks, respectively. After composting for 8 weeks the manure and manure plus could use as organic fertilizer. Random samples of manures, and manures plus were collected from the bulks, respectively. Then continued air-dried, ground, sieved and then analyzed for total N and total P. Total content of N and P of manures and manures plus used in the experiment is given in Table 1. Sulphate ammonium (SA), TSP, and KCl were used as inorganic sources at 200 kg N ha\(^{-1}\), 66 kg P ha\(^{-1}\), and 125 kg K ha\(^{-1}\), respectively. Following treatment were used in this experiment T1 (SA+TSP), T2 (cattle manure+inorganic), T3 (cattle manure plus), T4 (goat manure+inorganic), T5 (goat manure plus), T6 (poultry manure+inorganic), and T7 (poultry manure plus). All of plots was added KCl as basal fertilizer.

2.2. Site description and treatments application

The experiment of manure, manure plus and inorganic fertilizer treatment above for sweet corn was conducted on 250 m\(^2\) latosolic soil with low pH, N, P and K concentration in Batang District, Central Java Indonesia. The soil area was tilled and devided into 28 experimental units and designed as randomized block design with seven treatments (T1 to T7) with four replicates. The size of each plot was 2.0 m x 3.2 m. In each plot of small holes was made for two seed planting so that there were 40 holes (80 plants) per plot and each hole spaced 40 cm x 40 cm. Organic fertilizer was evenly spread onto soil surface by hand and immediately incorporated by tillage before sowing. Tillage was done to 20 cm depth by shovel and followed by raking. The next day after organic fertilizer treatment added, two sweet
corn seed (*Zea mays saccharatta*) were planted into each hole and added NP fertilizer according to the treatment. Each plot received basal fertilization of 125 kg K ha\(^{-1}\) as KCl [7], after which fertilization treatment was applied. The maize cobs were harvested 73 days after planting, and analyzed for sweet corn cobs production (without cornhusk), plant height, fresh stover production and fresh cornhusk production.

2.3. **Statistical Analyses**
Sweet corn cobs production, plant height, fresh production of stover and cornhusk were analyzed using analyses of variance (ANOVA). When significant differences among the treatments were found (p<0.05), the data were further using Duncan’s Multiple Range Test (DMRT).

3. **Results and Discussion**

3.1. **Chemical analyses**
Chemical analyses result of manure plus of cattle, goat, and poultry showed that concentration of N total (1.05, 1.40, 1.86%), and P total (2.20, 0.63, 2.25%) higher compared to manure of cattle, goat, and poultry only, respectively (Table 1). Because manure plus made from dung of cattle, goat, and poultry which added N-*Leucaena leucocephala* (200 kg N ha\(^{-1}\)), and P-RP (66 kg P ha\(^{-1}\)), respectively. Nevertheless, manures have different varieties in chemical composition of nutrition depending on the type, age, and the diet of livestock [16].

| Kind of manure     | Total N (%) | Total P (%) |
|--------------------|-------------|-------------|
| Cattle manure      | 0.95        | 1.34        |
| Cattle manure plus | 1.05        | 2.20        |
| Goat manure        | 1.30        | 0.54        |
| Goat manure plus   | 1.40        | 0.63        |
| Poultry manure     | 1.65        | 0.93        |
| Poultry manure plus| 1.86        | 2.25        |

**Conclusions**
Organic-N (*Leucaena leucocephala*) and nature-P (rock phosphate) enhanced the quality of manure if added at the initial fermentation process that was called manure plus. Organic-N and nature-P enriched manure application showed positive effects on plant growth and sweet corn production, stover and cornhusk production in Batang District of Central Java. The results showed that plant height and sweet corn production, stover and cornhusk production significantly affected by the treatment. Goat manure plus resulted in similar on plant growth and sweet corn production compared to manure+inorganic fertilizer. It was concluded that N-*Leucaena leucocephala* and P-RP enriched manure replaces inorganic fertilizer (SA+TSP).

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