The Effect of Organic Phosphorus and Nitrogen Enriched Manure on Nutritive Value of Sweet Corn Stover

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Abstract

The experiment aimed to evaluate the effect of some manure enriched with phosphorus (P) and nitrogen (N) organic ('manure plus') on crude protein and mineral production of sweet corn (*Zea mays saccharata*)and quality of fermented stover as livestock feed. A field experiment was conducted on a vertisol soil (low pH, nitrogen and low available Bray II extractable P). Randomized block design with 9 treatments in 3 replicates was used in this experiment. The treatments were T1(TSP), T2 (SA), T3 (TSP+SA), T4 (manure), T5 (manure+PR), T6 (manure+guano), T7 (manure+N-legume), T8 (manure+PR+N-legume), T9 (manure +guano+N-legume). Data were analyzed using analysis of variance (ANOVA) and the differences between treatment means were examined by Duncan Multiple Range Test (DMRT). Results of the experiment showed that the treatment significantly affected to the crude protein and calcium production of stover and nutrient concentration of fermented stover, but it is not affected to P production of stover. The result of DMRT showed that the effect of 'manure plus' was not significantly different on CP and Ca production of stover, mineral concentration, *in vitro* DMD and OMD of fermented stover, compared to inorganic fertilization. Conclusion, manure enriched with organic NP, resulted in similar on CP and Ca production of stover and nutrient concentration of fermented stover compared to inorganic fertilizer. Thus, organic-NP enriched manure could be an alternative and viable technology to utilize low grade of phosphate rock, guano and *Gliricidea sepium* to produce sweet corn in vertisol soil.

1. Introduction

Sweet corn (*Zea mays* var. *saccharata*) is utilized as raw materials for various uses with a majority for food, while corn stover and cornhusk are used for ruminants feed[1]. Sweet cornseed is used forfood ingredients while the remain i.e. corn stover and cornhusk are used for ruminants feed. Crop growth and yield in relation to application of different organic fertilizers has been widely reported [2]. Organic fertilizer from animal excreta or crop residue have been studied and shown to improve soil environment and fertility, activity of decomposer, promote crop yield, decrease green house gas emission and provide a carbon sink [3]. Organic fertilizer application is not as a substitute for inorganic fertilizers but as a complement because it contains macro nutrients, micro and organic acids and manure also acts as ameliorant. Application of organic fertilizers with the addition of inorganic fertilizers, increased soil fertility and crop production also saved the use of inorganic fertilizers [4]. This is in line with the Regulation of the Minister of Agriculture No.40/2007 that the purpose of organic material return or the provision of organic fertilizers equipped with inorganic fertilizers is to improve soil conditions and fertility.

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Cattle manure as organic fertilizer is widely applied in Indonesia. The drawback is that it is relatively low in phosphorus, nitrogen, and potassium compared to commercial fertilizer. The composition of cattle manure differs between fresh and composted manure and varies with type of cattle, age, composition of feed, rations, type of bedding, manure storage and handling [5]. Cattle manure quality can be improved by enrichment utilizing organic P source such as rock phosphate or guano (bat faeces) and N source such as *Gliricidea sepium* [6, 7, 8]. Manure application on the crop used in the combination with NP organic, in comparison to inorganic fertilizer, reduces the stringent quality of environment protection requirements, and minimizes the negative impacts of manure on soil pollution. Its also changes the consideration of manure from a waste to a resource product [9] and residual effects of applied organic P enriched manure can be used for the next growing season [10].

The availability of the organic P from phosphate rock (PR) or guano, and the availability of organic N from *G. sepium* can be enhanced by composting it together with the cattle manure. The addition of decomposing microbes could aid the decomposition of organic matter during composting. Effective microorganisms (EM), which available in liquid form, has been introduced in 1991. The major groups of microorganisms contained in the EM include filamentous fungi, yeast, lactic acid bacteria, and other soil bacteria [11] which could aid the decomposition of organic matter during composting. The objective of this research was to evaluate the effect of mixed organic P (rock phosphate, guano) or organic N (*G. s*epium) with manure on crude protein and mineral production of sweet corn (*Zea mays saccharata*)and nutrient of fermented stover as livestock feed.

2. Materials and Methods

2.1. Composted Manure and Inorganic Fertilizers as Treatment and Experimental Design

The nine treatments were (1) TSP, application inorganic fertilizer on 66 kg P ha^{-1}; (2) sulphate ammonium, inorganic fertilizer on 200 kg N ha^{-1}; (3) sulphate ammonium + TSP, application of inorganic fertilizer NP (200 kg N ha^{-1} + 66 kg P ha^{-}); (4) manure, application of manure organic fertilizer on 20 t ha^{-1}; (5) manure+ PR, manure enriched with P-PR equivalen to 66 kg P ha^{-1}; (6) manure+guano, manure enriched with P-guano equivalent to 66 kg P ha^{-1}; (7) manure+ N-legume, application of manure enriched with N-*Gliricidea sepium* equivalent to 200 kg N ha^{-1}; (8) manure+P-PR+N-legume, manure organic fertilizer enriched with P-PR and N-*Gliricidea sepium* equivalent to 66 kg P ha^{-1} and 200 kg N ha^{-1}; (9) manure+guano+N-legume, application of manure organic fertilizer enriched with P-guano and N-*Gliricidea sepium* equivalent to 66 kg P ha^{-1} and 200 kg N ha^{-1}. Sulphate ammonium (SA), TSP, phosphate rock, guano, *Gliricidea sepium*, and manure were applied as the treatment, and KCl was added as basal fertilizer. Manure organic fertilizer made from cattle dung and urine mixed with waste of feed, and inoculated with biodecomposer (EM-4). After composting for one month only the manure could used as organic fertilizer, with or without enriched with organic-NP.

2.2. Study Area and Composted Manure Application

The experiment of organic and inorganic fertilizers treatment above for sweet corn was conducted on 350 m2 vertisol soil with low pH, P and N concentration in Sragen District, Central Java-Indonesia. The soil area was tilled and divided into 27experimental units and designed as randomized block design with nine treatments (T1 to T9) with three replicates. The size of each plot was 1.6 m x 2 m. In each plot a small holes was made for seed planting so that there were 20 holes per plot and each hole spaced 40cm x 40cm. Organic and inorganic fertilizer were 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. Each plot received basal fertilizationof 125 kg K/ha as KCl [8], after which fertilization treatment was applied. The next day after the treatment two sweet corn seed (*Zea mays saccharata*) was planted into each holes. The sweet corn was harvested 70 days after planting, and analyzed for nutrient production (nitrogen and phosphorus) of stover and fermented

stover. To measure nitrogen (N), phosphorus (P), and Caconcentration [12], samples were chopped, sub-sampled, and oven-dried at 70^0C for 48 h to constant weight. Samples were finally ground and analyzed for N and mineral Ca, P production of stover, mineral (Ca, P) and *in vitro* dry matter digestibility (DMD) and organic matter digestibility (OMD) of fermented stover.

2.3. Statistical Analyses

Crude protein and mineral (Ca, P) production of stover, nutrient concentration, IDMD and IOMDwere analyzed using one way analysis of variance (ANOVA). When significant differences among the treatments were found ($p<0.05$), the data were further tested using Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1. Chemical analysis

Chemical analysis result of soil and manure fertilizer showed that soil belong to deficient in N (0,17-0,20% N) and P (6,10-6,60 ppm P_2O_5). Manure analyses showed that concentration of N and P total (1,51%-1,75%) and (1,13-1,97%), respectively. Its manure quality was higher compared to Soelaeman (2008) 0,55% N dan 0,12% P total, respectively.This was affected by raw materials of organic fertilizers [13]. Manure made from cattle dung mix with urine and feed residue inoculated with effective microorganisms (EM-4). The major groups of microorganisms contained in the EM include filamentous fungi, yeast, lactic acid bacteria, and other soil bacteria [3, 11], which has the ability to increase decomposition process, mobilisation and mineralisation of nutrient [14]. Ratio of C/N of six manure treatment were 15,17; 14,66; 13,58; 12,83; 13,52 and 12,64%, respectively. According to [15], international quality standard of manure C/N ratio was below 20, and could be used for fertilization [16].

3.2. *Crude Protein and Mineral Production of Stover and Nutrient of Fermented Stover.*

Result showed that both of the CP and Ca production of stover were significantly influenced by the treatments. Phosphorus production of stover was not significantly influenced by the treatments.
Table 1 showed that CP production with SA(T2) was significantly higher compared to TSP (T1). Fertilization treatment of SA (T2) which KCl as basal fertilization had the high CP production of stover and that treatment contained nutrients sufficient enough to produce high CP. Nitrogen (SA) is very influential on plant growth [17], so that if there is a deficiency of N (T1) then the growth of theplant is inhibited and experienced chlorosis [18]. Availability of essential nutrients in adequate quantity and form enhanced protoplasmic development and cell proliferation. These culminated in proper crop growth and development [19].

Manure enriched with N, P or NP organic (T6, T7, T8, T9) showed that CP production of sweet corn stover (Table 1) and Ca production of stover (Table 2) were not different compared to inorganicfertilization of T2 (SA) and T3 (TSP+SA). This implies that these organic fertilizers contained adequate nutrients required for normal plant growth and development as contained in the NPK. Manure application on the crop used in the combination with organic NP, in comparison to inorganic fertilizer, reduces the stringent quality of environment protection requirements, minimizes the negative impacts of manure on soil pollution and changes the consideration of manure from a waste to a resource product [19]. The use of organic fertilizer and combination with inorganic (KCl)(T4, T5,T6, T7, T8, T9) showed similar effect on CP (Table 1) and Ca (Table 2) of stover compared to TSP+SA (T3). However, its not affected significantly on P production of stover (Table 2). That's mean application of various inorganic and organic fertilizers had equivalent ability on P production of stover. Cattle manure quality can be improved by enrichment utilizing organic P source

such as phosphate rock or guano (bat faeces) and N source such as *Gliricidea sepium* [6, 7, 8]. Application of organic fertilizers with the addition of inorganic fertilizers, increased soil fertility and crop production also saved the use of inorganic fertilizers [4]. Manure increased the nutrient uptake of sweet corn stover when combined with inorganic fertilizers [20].

Table 1. Crude Protein Production of Sweet Corn Stover with Organic and Inorganic Fertilization

Treatments	Crude protein production kg/plot (3.2 m^2)
T1 (TSP)	380.50 ± 35.02[b*]
T2 (SA)	631.62 ± 57.53[a]
T3 (TSP+SA)	584.42 ± 52.36[ab]
T4 (manure)	402.53 ± 28.75[ab]
T5 (manure+P-PR)	445.84 ± 11.63[ab]
T6 (manure+P-guano)	483.07 ± 34.03 [ab]
T7 (manure+N-legume)	422.10 ± 26.53 [ab]
T8 (manure+P-PR+N-legume)	415.39 ± 57.46 [ab]
T9 (manure+P-guano+N-legume)	486.75 ± 41.75 [ab]

*Significantly different ($p<0.05$)

Table 2. Mineral Production of Sweet Corn Stover with Organic and Inorganic Fertilization.

Treatments	Ca production (g/plot)	P production (g/plot)
T1. (TSP)	16.02 ± 2.05 b*	24.48 ± 1.47
T2. (SA)	25.11 ± 2.77 ab	35.23 ± 2.64
T3. (TSP+SA)	25.48 ± 3.12 ab	39.20 ± 4.67
T4. (Manure)	19.97 ± 0.98 ab	31.04 ± 1.64
T5. (Manure+P-PR)	20.11 ± 1.23 ab	31.20 ± 1.78
T6. (Manure+ P-guano)	24.20 ± 0.77 ab	32.79 ± 1.68
T7. (Manure+N-legum)	27.70 ± 2.36 ab	35.24 ± 1.11
T8. (Manure+P-PR+N-legum)	24.37 ± 2.25 ab	32.02 ± 4.44
T9. (Manure+P-guano+N-legum	29.32 ± 2.99 a	38.20 ± 3.56

* Significantly different ($p< 0.05$)

3.3. *Mineral concentration in vitro DMD and OMD of fermented stover*

Mineral concentration, *in vitro* DMD and OMD of fermented stover were significantly influenced by the treatments. Manure and organik N-P enriched manure (T4, T5,T6, T7, T8, T9) showed that Ca and P concentration of fermented stover (Table 3) and *in vitro* DMD and OMD of fermented stover (Table 4) were not significantly different compared to inorganic fertilization of T3 (TSP+SA). The carbonic acid and organic acid produced during the decomposition of organic matter solubilized insoluble phosphate in P organic (phosphate rock, guano), resulting in the release of phosphate and calsium into the solution [21]. That's mean application of some organic N-P enriched manure had equivalent ability on mineral concentration, *in vitro* DMD and OMD of fermented stover [22].

Table 3. Mineral Concentration of Fermented Sweet Corn Stover

Treatments	Ca concentration (%)	P concentration (%)
T1. (TSP)	0.41 ± 0.03 b*	0.27 ± 0.018 abc
T2. (SA)	0.58 ± 0.04 a	0.23 ± 0.006 bc
T3. (TSP+SA)	0.55 ± 0.04 ab	0.22 ± 0.009 c
T4. (Manure)	0.51 ± 0.02 ab	0.24 ± 0.013 abc
T5. (Manure+P-PR)	0.58 ± 0.05 ab	0.32 ± 0.012 a
T6. (Manure+P-guano)	0.43 ± 0.04 ab	0.25 ± 0.007 abc
T7. (Manure+N-legum)	0.51 ± 0.03 ab	0.31 ± 0.035 ab
T8. (Manure+P-PR+N-legum)	0.46 ± 0.04 ab	0.23 ± 0.012 abc
T9. (Manure+P-guano+P-legum	0.50 ± 0.07 ab	0.23 ± 0.002 abc

* Significantly different ($p < 0.05$)

Table 4. *In vitro* Dry Matter Digestibility and Organic Matter Digestibility of Fermented Stover

Treatments	DMD (%)	OMD (%)
1. TSP	64.68 ± 0.59 a	62,84 ± 0.61 a*
2. SA	64.10 ± 1.44 a	62,82 ± 1.49 a
3. TSP+SA	59.16 ± 2.17 ab	56.07 ± 2.16 ab
4. Manure	55.37 ± 0.59 b	53.46 ± 1.00 ab
5. Manure+P-PR	58.11 ± 2.00 ab	56.32 ± 2.37 ab
6. Manure+P-guano	55.23 ± 0.10 b	51.71 ± 1.18 b
7. Manure+N-gamal	61.19 ± 1.69 ab	59.89 ± 1.82 ab
8. Manure+P-PR+N-gamal	61.88 ± 1.54 ab	60.23 ± 1.72 ab
9. Manure+P-guano+N-gamal	63.51 ± 0.33 ab	62.20 ± 0.74 a

* Significantly different ($p < 0.05$)

4. Conclusion

Organic-N (N-legume) and organic-P (RP, guano) and organic-NP (manure+P-PR+N-legume; manure+P-guano+N-legume) enriched manure resulted in similaron CP and Ca production of stover, mineral concentration, *in vitro* DMD, and OMD of fermented stover compared to TSP+SA (T3). Application of organic NP enriched manurecould be a promising organic fertilizer to replace inorganic fertilizer (TSP, sulphate ammonium) to produce sweet corn in vertisol soil.

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