Improvement of Plant Growth and Production of Waxy Corn with Organic-NP Enriched Manure and Inorganic Fertilizer in Sragen District of Central Java Indonesia

D R Lukiwati, F Kusmiyati, Yafizham, S Anwar

Faculty of Animal and Agricultural Sciences, Diponegoro University, Indonesia,

Corresponding author : drlukiwati_07@yahoo.com

Abstract. Organic and inorganic fertilizer are important for crop productivity. Waxy corn (Zea mays ceratina L) is used under crop-livestock system (CLS) in Indonesia. The characteristic of CLS is crop yield for food, stover and corn-husk for livestock feed, cattle dung for manure as organic fertilizer. The quality of manure could be enhanced by adding organic-N (Gliricidia sepium) and organic-P (rock phosphate, guano) at the initial fermentation process that was called manure plus. Present study investigated the effects of organic-NP enriched manure application on plant growth and waxy corn production, stover and corn-husk production in vertisol soil Sragen District, Central Java. The experiment was conducted using a randomized complete block design with seven treatments and four replicates, T1 (inorganic-NPK), T2 (manure), T3 (manure+RP), T4 (manure+guano), T5 (manure + legume), T6 (manure+ RP+legume), and T7 (manure+guano+legume). The results showed that plant height and waxy corn production non-significantly affected by the treatment. Fresh waxy corn stover production and fresh corn-husk production significantly affected by the treatments. Manure plus resulted in similar on fresh waxy corn stover production and fresh corn-husk production compared to inorganic-NP fertilizer. It was concluded that organic-NP enriched manure replaces NPK as inorganic fertilizer.

Keywords: plant growth, waxy corn, organic-NP, manure, inorganic fertilizer

1.Introduction
Sticky maize or waxy-corn (Zea mays ceratina L.) is a variety of maize with a high amiloprotease content 90% [1]. Waxy-corn is used by farmer under crop-livestock system (CLS) in Indonesia especially in Central Java. The characteristic of CLS is crop yield for food, stover for ruminant feed and cattle dung for manure as organic fertilizer. Applying fertilizers, particularly in the inorganic form, in excess of plant requirement can increase the chances of fertilizer loss and environmental pollution. Organic manures, apart from improving physical and biological properties of soil, help in improving the efficiency of chemical fertilizers. The use of organic fertilizers made up of various composted materials, is now established as a key strategy not only for improving soil organic matter contents and nutrient supply to plant but also for reducing the input cost of mineral fertilizers and promoting healthier environments [2].

Major plant nutrient such as nitrogen and phosphorus is one of the primary factors limiting crops yield [3]. Therefore, application of N and P fertilizers is essentially required to improve crop yield.
Manure in general low in most of major nutrients, and organic nitrogen (legume) and organic phosphorus (rock phosphate, guano) can advantageously compensate the imbalance of manure on N and P nutrients [4]. The quality of manure could be enhanced by adding organic phosphorus sources (RP, guano) [5] and organic-N such as *Gliricidia sepium* [6, 7] at initial phase of fermentation process. 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 [8].

Main problem in using the nature-P (organic-P) is to solubilize and enhance availability of P content [9]. However, if natural P is allowed to react with organic acids produced during composting, a major part of natural P could be solubilized for plant uptake [10]. It is well documented that during composting process of organic waste a variety of organic acids are released. The extent of nature-P solubilization by composting material depend on many factors such as type of nature P fertilizer.

Deposits of nature P (RP, guano) in Indonesia such as Cirebon District (West Java), Pati District (Central Java) and Gresik District (East Java). Guano is decomposed bat manure, and desert bat manure guano escapes leaching in caves preserving its nutrients [11]. Meanwhile, rock phosphate a naturally occur mineral source of insoluble phosphate, and the solubility can be increased by organic acids is the major advantage of composting through [12, 13]. Effectiveness of organic-P fertilizers was increased by presence of NK fertilizer as well [4]. An integrated use of inorganic fertilizers with organic manure is a sustainable approach for efficient nutrient usage which enhances efficiency of the chemical fertilizers while reducing nutrient losses to improve crop productivity on sustainable basis [14, 15]. Keeping all these aspects in consideration, the present study was therefore conducted to evaluate the effect of manure plus (organic-NP enriched manure) and inorganic fertilizer (NPK) on plant growth and waxy corn production, fresh production of stover and corn husk in vertisol (grumusol) soil.

2. Materials and Methods

2.1. Organic-NP enriched manure and inorganic fertilizers as treatment

The materials used were cow dung collected from local farmer, RP and guano collected from the community mining in Pati District of Central Java. *Gliricidia sepium* as legume-N collected from village in Sragen District of Central Java. All of its material for the formulation of organic-P enriched manure and organic-N enriched manure and organic-NP enriched manure. Organic-P such as RP and guano (66 kg P ha⁻¹), organic-N was N-legume (200 kg N ha⁻¹) and cow dung (20 t ha⁻¹) were mixed and added effective microorganism (EM) and then composted anaerobically for 6 weeks and called manure plus. Meanwhile the manure fertilizer (without organic-NP) was made from cow dung mixed with EM and then composted anaerobically for 6 weeks as well. After composting for 6 weeks the manure could use as organic fertilizer, with or without enriched with organic-NP. Random samples of manure, P-RP enriched manure (manure + RP) and P-guano enriched manure (manure + guano) and N-legume enriched manure (manure + legume) were collected from the bulks, respectively. Then continued air-dried, ground, sieved and then analysed for total organic matter (OM), organic C (OC), total N, total P, total K and C:N ratio. Sulphate ammonium (SA), TSP and KCl were used as inorganic sources at 200 kg N ha⁻¹, 66 kg ha⁻¹ and 125 kg K ha⁻¹, respectively. Following treatments were used in this experiment T1 (SA+TSP+KCl), T2 (manure), T3 (manure+RP), T4 (manure +guano), T5 (manure+legume), T6 (manure+RP+ legume), T7 (manure+guano+legume).

2.2. Site description and treatments application

The experiment of manure, manure plus and inorganic fertilizers treatment above for waxy-corn was conducted on 250 m² vertisol (grumusol) soil with low pH, N, P and K concentration in Sragen District, Central Java-Indonesia. The soil area was tilled and divided 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 2.5 m x 2.5 m. In each plot a small holes was made for two seed planting so that there were 25 holes (50 plants) per plot and each hole spaced 50 cm x 50 cm. Organic 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. The next day after the organic fertilizer treatment added, two waxy-corn seed (Zea mays ceratina L) was planted into each holes and added NPK fertilizer according to the treatment. The maize cobs was harvested 10 weeks after planting, and analysed for waxy-corn cobs production (without corn-husk), plant height, fresh stover production and fresh corn-husk production.

2.3. Statistical Analyses
Waxy-corn cobs production, plant height, fresh production of stover and corn-husk were analysed using one way analyses 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 analyses
Chemical analyses result of organic-N enriched manure fertilizer (manure + legume) showed that concentration of N total (1.54%) higher compared to another manure treatment. Because analysed result of Gliricidia sepium in this study contain 2.87% N. Organic-P enriched manure (manure + RP) showed that concentration of P total (2.02%) higher compared to another manure treatment. The treatment of organic-N enriched manure (manure + legume) and organic-NP enriched manure (manure +guano + legume) have similar in K total (1.22%) and higher compared to another manure treatment. Its manure quality was higher compared to [16] 0.55% N and 0.12% P total, respectively. Meanwhile, manure+RP quality was higher compared to manure+guano, except N total. Because guano material contain 0.35% nitrogen as well in this study. It is very likely that during composting of cow dung, organic acids were produced which solubilized P of RP and P of guano. This may imply that manure+RP can act as excellent source of P [12]. Manure+RP product proved better than manure+guano product in terms of release of P [17].

3.2. Waxy-corn cobs production and plant height
The data summarizes in Table 1 showed that production of waxy-corn cobs and plant height were not significantly influenced by the treatments. All the treatment using N and P at the same level 200 kg N ha$^{-1}$ and 66 kg P ha$^{-1}$, respectively. However, each one tonne of manure, on an average contain 50-100 kg N, 50 kg P$_2$O$_5$ and 20 kg K$_2$O [18]. This suggested that nutrient value addition with organic-NP enriched manure could provide similar effect compared to inorganic-NPK on waxy-corn cobs production and plant height. Similar result reported by [4], effectiveness of P-fertilizers was enhanced by presence of N fertilizer. Application of organic fertilizer could enhanced the production of secondary metabolites compared to the use of inorganic. The nitrate content was reduced under organic fertilizer as well [19]. It is mean optimizing the nutritional composition with minimal chemical residues on foods produced through environmentally friendly agricultural practices. Organic-NP enriched manure could be an alternative and viable technology to utilize low grade of rock phosphate, guano and Gliricidia sepium to produce maize in vertisol soil [20].

3
Table 1. Waxy corn cob production and plant height with organic and inorganic fertilization.

| Treatments               | Waxy corn cob production (kg/plot) | Plant height (cm) |
|--------------------------|------------------------------------|-------------------|
| SA+TSP+KCl               | 6.70 ± 0.7                         | 252.80 ± 17.5     |
| Manure                   | 6.40 ± 1.3                         | 227.00 ± 15.4     |
| Manure + RP              | 6.60 ± 0.7                         | 239.50 ± 14.8     |
| Manure + guano           | 6.80 ± 1.1                         | 242.80 ± 14.8     |
| Manure + legume          | 6.50 ± 1.2                         | 250.30 ± 22.7     |
| Manure + guano + legume  | 7.40 ± 1.5                         | 252.80 ± 17.5     |

Management system that use manure+legume may increase the availability of P by decreasing the sorption of added P to soils [21]. Organic manures improves soil physical-chemical properties that may have a direct or indirect effect on plant growth and yield properties [22].

3.3. Fresh production of stover and corn-husk

The data of Table 2 showed that fresh production of stover and corn-husk was significantly affected by the treatments. Manure plus resulted in similar on fresh production of stover and corn-husk compared to NPK fertilizer (T1). Fertilization treatment using N and P at the same level of 200 kg N ha\(^{-1}\) and 66 kg P ha\(^{-1}\), respectively. However, guano and legume contain nitrogen as well, 0.35% and 2.87% respectively. Each one tonne of manure, on an average contain 50-100 kg N, 50 kg P\(_2\)O\(_5\) and 20 kg K\(_2\)O [18]. This suggested that (manure plus) could release nutrient in similar level compared to SA+TSP+KCl, and also enhanced the nutrient uptake. Manure nutrient could be enhanced by adding organic-P (RP, guano) [5] and organic-N (Gliricidia sepium) at initial phase of decomposition process [6,7]. The externally applied nitrogen supported native available nitrogen that resulted in higher nitrogen concentration that was sufficient to meet the requirement, and vegetative growth supported [23]. Management system that use manure+legume may increase the availability of P by decreasing the sorption of added P to soils [21]. Organic manures improves soil physical-chemical properties that may have a direct or indirect effect on plant growth and yield properties [22].

Table 2. Fresh production of stover and corn-husk with organic and inorganic fertilization.

| Treatments               | Fresh stover production kg/plot | Fresh corn-husk production kg/plot |
|--------------------------|---------------------------------|------------------------------------|
| SA+TSP+KCl               | 24.50 ± 2.30 abc                | 4.30 ± 1.70 bc                     |
| Manure                   | 17.90 ± 2.00 d                  | 6.30 ± 1.50 a                      |
| Manure + RP              | 19.30 ± 3.40 cd                 | 5.60 ± 0.70 ab                     |
| Manure + guano           | 21.40 ± 3.80 bcd                | 3.80 ± 0.50 c                      |
| Manure + legume          | 23.40 ± 5.50 abc                | 4.40 ± 1.10 bc                     |
| Manure + RP + legume     | 25.50 ± 2.50 ab                 | 4.00 ± 0.70 bc                     |
| Manure + guano + legume  | 27.30 ± 2.40 a                  | 4.20 ± 1.00 bc                     |

Means followed by the same letter for each factor in a column are not different (P>0.05)

4. Conclusion

Maize cob production and plant height was not affected by fertilization treatment. Manure plus or organic-NP enriched manure resulted in similar on fresh stover production and fresh corn-husk production compared to inorganic fertilizer (SA+TSP+KCl). Application of organic-NP enriched manure may be a promising organic fertilizer to replace inorganic-NPK and reduce cost of crops production as well.
5. References

[1] Ramansyah M, Hidayati N, Juhaeti T and Sugiharto A 2013 Effect of bio-organic fertilizer on productivity improvement of well adapted local maize (Zea mays ceratina L.) variety ARPN J. of Agroc. and Biol. Sci. 8(3) 233

[2] Ahmad R, Khalid A, Arshad M, Zahir ZA and Naveed M 2006 Effect of raw (uncomposted) and composted organic waste material on growth and yield of maize (Zea mays L) Soil Environment 25 135

[3] Zaidi A, Khan MS, Ahemad M and Oves M 2009 Plant growth promotion by phosphate solubilizing bacteria Acta Microbiol. Immunol. Hungarica 56 263

[4] Ramilison R 2001 The effect of local rock phosphate fertilizer on yield of maize in P-deficient soils of the Central Plateau of Madagascar In: Seventh Eastern and Southern Africa Regional Maize Conference 11-15 February 394

[5] Lukiwati DR, Purbajanti ED, and Pujaningsih RI 2014 Sweet corn production and nutritive value of stover with manure enriched with rock phosphate fertilizer and biodecomposer J.of Agric. Sci. and Tech. A. 4(10) 839

[6] Widjajanto D 2013 Pengaruh pemberian bahan organik daun gamal (Gliricidia sepium) terhadap beberapa karakteristik fisik inseptisols Lembah Pulu. J. Sains & Tek. 15(1) 147

[7] Shridhar MK, Go A, and Oo A 2001 Alternate nitrogen amendments for organic fertilizers Scientific World J. 19(1) Suppl 2 142

[8] Annicchiarico G, Caternolo G, Rossi E and Martiniello P 2011 Effect of manure vs fertilizer inputs on productivity of forage crop models. Int. J. Environ. Res. Public Health 8 1893

[9] Khan AA, Jilani G, Akhtar MS, Saqlan SM and Rasheed M 2009 Phosphorus solubilizing bacteria: occurrence, mechanisms and their role in crop production J. Agric. Biol. Sci. 1 48

[10] Singh H and Reddy MS 2011 Effect of inoculation with phosphate solubilizing fungus on growth and nutrient uptake of wheat and maize plants fertilized with rock phosphate in alkaline soils European J Soil Biol. 47 30

[11] Wireko-Manu, FD and Amamoo C 2017 Comparative studies on proximate and some mineral composition of selected local rice varieties and imported rice brands in Ghana Agric. and Food Sci. Res. 4(1) 1

[12] Imran MR, Waqas ZIH, Nasli B, Shaharoona and Arshad M 2011 Effect of recycled and value-added organic waste on solubilization of rock phosphate in soil and its influence on maize growth Date of access: 11/07/2017. http://www.fspublishers.org/

[13] Qureshi SA, Rajput A, Memon M and Solangi MA 2014 Nutrient composition of rock phosphate enriched compost from various organic waste. E3J.of Sci.Res., 2(3) 47

[14] Schoebitz M and Vidal G 2016 Microbial consortium and pig slurry to improve chemical properties of degraded soil and nutrient plant uptake. J.Soil Sci. Olant Nutr. 16(1) 226

[15] Mahmood F, Khan I, Ashraf U, Shahzad T, Hussain S, Shahid M, Abid M and Ullah S 2017 Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. J.of Soil Sci. and Plant Nutrition 17(1) 22

[16] Soelaeman Y 2008 Efektivitas pupuk kandang dalam meningkatkan ketersediaan fosfat, pertumbuhan dan hasil padi dan jagung pada lahan kering masam. J. Tanah Trop. 13(1) 41

[17] Nishanth D and Biswas DR 2008 Kinetics of phosphorus and potassium release from rock phosphate and waste mica enriched compost and their effect on yield and nutrient uptake by wheat (Triticum aestivum). Bioresour. Technol. 99 3342

[18] Sekhar DMR and Aery NC 2001 Phosphate rock with farmyard manure as P fertilizer in neutral and weakly alkaline soils Current Sci. 80(9) 1113
[19] Ibrahim MH, Jasfar HZE, Karimi E and Ghasemzadeh A 2013 Impact of organic and inorganic fertilizers application on the phytochemical and anti-oxidant activity of Kacip Fatimah (Labisia pumila Benth). J. of Molecules 18 10973

[20] Lukiwati DR, Pujaningsih RI and Murwani R 2018 Effect of organic phosphorus and nitrogen enriched manure on nutritive value of sweet corn stover. IOP Conf. Series: Earth and Environ. Sci. 119 01

[21] Ohno T and Crannell BS 1996 Green and animal manure-derived dissolved organic matter effects on phosphorus sorption. J. Environ. Qual. 25 1137

[22] Lima DLD, Santos SM, Schrerer HW, Schneider RJ, Duarte AC, Santos EBH and Esteves VI 2009 Effects of organic and inorganic amendments on soil organic matter properties Geoderma 150 38

[23] Bhatt PS 2012 Response of sweet corn hybrid to varying plant densities and nitrogen levels African J. of Agric.Res. 7(46) 6158