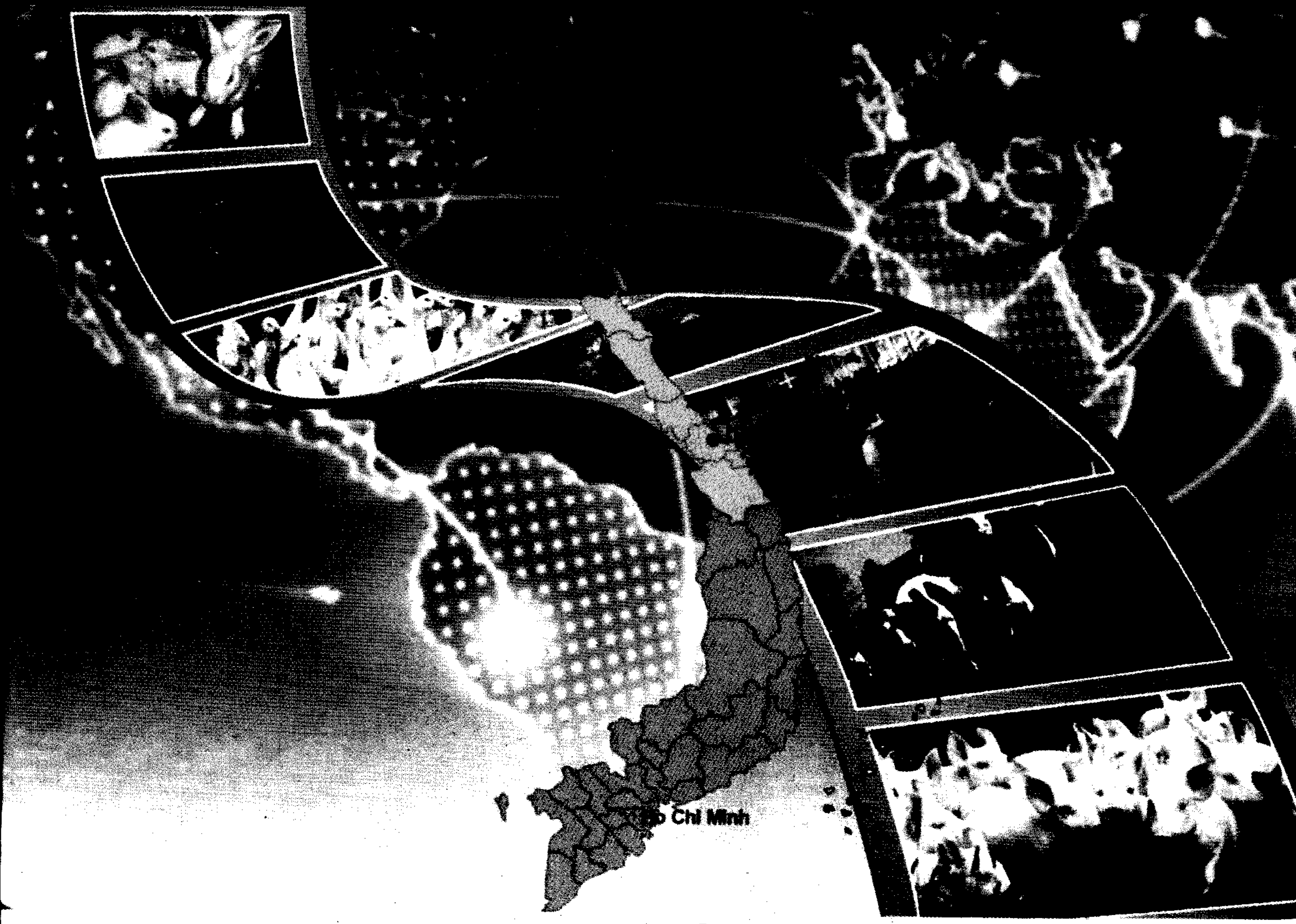
TẠP CHÍ KHOA HỌC KỸ THUẬT

CHĂN NUÔI

Journal of Animal Husbandry Sciences and Technics (JAHST)

Năm thứ 27

ISSN 1859 - 476X



KHOA HỌC - CÔNG NGHỆ

Special issue APE2019: ANIMAL PRODUCTION AND ENVIRONMENT

HỘI CHĂN NUÔI VIỆT NAM

ANIMAL HUSBANDRY ASSOCIATION OF VIETNAM (AHAV)

No. 249

September 2019

IMPROVEMENT OF MAIZE STOVER NUTRITION AS RUMINANT FEED WITH MANURE PLUS AND INORGANIC FERTILIZER

Dwi Retno Lukiwati[1*]

Submitted Jul 17, 2019 - Accepted Aug 19, 2019

ABSTRACT

Zea mays in Indonesia is used by farmer under crop-livestock integrated farming system (CLIFS). Integrated farming system hold special position as in this system nothing is wasted, the by-product of one system becomes the input for other. Crop yield for food and crop residues (stover and cornhusk) can be used for livestock feed, while farmyard manure as organic fertilizer can enhance agriculture productivity by intensifying nutrients that improve soil fertility, reducing the use of chemical fertilizers. The quality of farmyard manure could be enhanced by adding organic phosphorus (P-guano, P-phosphate rock) and organic nitrogen (N-legume) at initial phase of decomposition process, that was called as manure plus. Manure plus being locally available is cheaper sources of nutrient availability, and could be an alternative organic fertilizer to replace TSP and urea and reduce cost of crops production as well. Application of manure plus to improve maize stover and cornhusk nutrition as ruminant feed have been done since 2013 until 2018 in Central Java Indonesia will be presented in this paper.

Keywords: *Maize, manure, nitrogen, phosphorus, nutrient.*

1. INTRODUCTION

Zea mays is one of the key food crops in the world, serving as a staple food and main economic contributor for the people of the Asian continent. Sweet corn (*Zea mays* var. *saccharata*) is a type of speciality corn used as fresh or canned vegetable. It has sugar content greater than 25% during the milking stage (Singh and Reddy, 2011) with milky and sweet grain (Silva *et al.*, 2007). Another variety of maize is sticky maize or waxy corn (*Zea mays ceratina* L.). It is a variety of maize with high amylopectin content 90% (Ramansyah *et al.*, 2013). Sweet corn and sticky maize are utilized as raw materials for various uses also with a majority for food, while corn stover and cornhusk are used for ruminants feed in the tropics. Sweet corn and sticky maize are used by farmers 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. The sweet corn can be harvested in 70-75 days after planting, while sticky maize in 75-80 days after planting. Both the cornhusk and stover of sweet corn and sticky maize have moisture content between 70-80% (Silva *et al.*, 2007; Lukiwati *et al.*, 2019).

Most of the soil in Indonesia that cultivated for crops production is deficient in P and N. An insufficiency of P and N in the medium from which the crops its mineral nutrition results in retarded growth and reduced development. Phosphorus and nitrogen deficiency can be corrected by applying P and N fertilizer to the soil at or before sowing (Lukiwati, 200 Abdullah, 2009). Superphosphate (SP) and urea fertilizer is used to improve soil fertili in Indonesia. Superphosphate-36 contain 36% P_2O_5, with the P in a water-soluble forn However, the high cost of SP is now focusin attention on rock phosphate (RP) or guan fertilizer. Finely ground RP is an apatite miner not readily soluble in water, and when added acid soils, the solubilization of RP is increase The availability of organic P is enhanced unc acidic conditions in the soil.

Reactive RP when directly applied at init rates of between 80-360kg P_2O_5/ha, not o increased yields of corn, but resulted in simi yields compared to SP (Nassir, 2001). R phosphate and SP fertilizers increased ma grain yield, and dry matter (DM) yield of ma

[1] University of Diponegoro Semarang, Central Java, Indonesia
[*] Corresponding author: Dr. Dwi Retno Lukiwati, Faculty of Animal and Agricultural Sciences, University of Diponegoro Semarang, Central Java, Indonesia. Phone: +62248156660889; E-mail: drlukiwati_07@yahoo.com

stover over those of control that did not receive P fertilizer. Phosphorus fertilizer could increase the plant growth, especially if the P nutrient is a major limiting factor to the plant production. Assumedly, the solubilization of RP on 300kg P_2O_5/ha increased and similar with SP on the same level. Therefore, an expensive P source (SP) can be replaced by RP when the application of the later on 300kg P_2O_5/ha (Lukiwati, 2002).

Most of the studies conducted on farmyard manure and organic-P and organic-N were done as separated fertilizer, while only a view work focused on the aspects of using organic-NP enriched manure to improve maize nutritive value of stover and cornhusk.

2. CROP LIVESTOCK INTEGRATED FARMING SYSTEM

Indonesia is considered as an agricultural country where agriculture has long been serving as the back bone of its economy. Predominant characteristics of Indonesian grass-root farming systems are family based, small holdings, small capital, subsistence crop and traditional (non-mechanized) management. Human and animal remain predominant power sources of farm work in Indonesia. Increasing inputs of chemicals and fertilizers in some agricultural production systems may pose a threat to the natural areas surrounding farmlands. Therefore, the solution is to continue increasing the production value while at the same time to minimize the environmental damage and to conserve the resources, as well as reduce poverty, hunger and malnutrition. Integrated farming system (IFS) might be one of the best approaches to be implemented in practice of sustainable agriculture production and management system (Syuaib, 2016). Crop-livestock integration (CLI) may represent a model of sustainable farming according to principles of nutrient recycling and efficient use of land and resources (Moraine *et al.*, 2014). Integrated farming systems hold special position as in this system nothing is wasted, the by-product of one system becomes the input for other. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, and reducing the use of chemical fertilizers (Lukiwati *et al.*, 2018; Lukiwati *et al.*, 2018; Lukiwati *et al.*, 2019). Nutrient cycling and soil fertility can be improved at field and farm levels by animal-waste recycling and by including organic-NP (Witjaksono *et al.*, 2018).

Indonesia has no other option for achieving national food security than to manage its available and suitable sub-optimal lands for food production (Mariyono, 2014). The availability of land for agriculture in the moment and the future will be in sub-optimal land which has low pH and poor nutrients. The increasing pressure on land and the growing demand for livestock products in Indonesia makes it more essential to ensure the effective use of land and feed resources, including crop residues. An integrated crop-livestock farming system represents a key solution for increasing soil productivity, enhancing crop and livestock production, and safeguarding the environment through prudent and efficient resource use (Soelaiman and Maswar, 2014).

Indonesia has a higher density of cattle, buffalo, sheep and goats compared to other Southeast Asian countries. Livestock contribute 5-41% of farmer's income in the wet and dry agro-ecological zone and 60% in semi-arid zones. There is a tendency of farmers to consider livestock as household banks, easily liquidated when money is required (Nimwegen *et al.*, 2009). Integrated farming systems hold special position as in this system; the byproduct of one system becomes the input for other. Food crop residues such as straws or other biomass provide a suitable fodder for cattle and other ruminants, while occasionally, the food crop provides supplementary grain feed for productive livestock. On the other hand, livestock waste in the form of manure and urine is the source of soil organic matter and fertilizer. Manure usually applied directly to the soil as a source of organic fertilizer to improve soil productivity and crop yields (Gupta *et al.*, 2012). Recent research in various regions of the world has indicated that ICLS can enhance sustained crop and livestock production by efficiently using agriculture system resources (Liu *et al.*, 2012). Livestock are important in maximizing benefits because they turn crop residue into dollars while further improving the soil by depositing manure. Manured soils also were shown to be more porous and have lower bulk density (a measure of compaction) and higher aggregate stability than fertilized soils (Edmeades, 2003). Soil micro-organisms increase as organic matter increases, further improving the health of the soil and the crops grown on it (Coffey and Mumma, 2014).

Livestock production is a function of feed availability and quality. Livestock ruminants in general are fed on poor quality forages, and pasture produced on relatively infertile lands in the tropics. Cattle grazing P deficient areas typically develop symptoms of a phosphorosis which are reflected as retarded growth, poor reproductive performance, reduced milk yield, and bone abnormalities (Winks, 1990). Most of the studies conducted on farmyard manure and organic-P and organic-N were done as separated fertilizer, while only a view work focused on the aspects of using organic-NP enriched manure to improve maize nutritive value of stover and cornhusk.

3. PHOSPHORUS FERTILIZER

In commercially oriented livestock production, superphosphate fertilizer is applied to increase the forage production on non-productive land in Indonesia. However, the high cost of SP is now focusing attention on RP fertilizer. RP is a natural P source, it is relatively cheaper than SP and its locally available. There are RP deposits in Cirebon (West Java), Magelang/Pati (Central Java), and in Gresik (East Java). According to Kerridge and Ratcliff (1982), RP can also be used as a maintenance fertilizer for pasture species on acid soils in humid areas. RP contains P in a form that is not readily soluble in water but soluble in neutral ammonium citrate solution making it slowly available to plants. Water-insoluble P fertilizer do not all behaves in the same way as SP. Finely ground RP is an apatite mineral and when added to acid soils, the solubility of RP is increased so that below pH 5.5 it begins to make a significant contribution, and on really acid soils it can be a useful source of phosphate.

To alleviate the P deficiency in acid latosolic soil, superphosphate (SP) or rock phosphate (RP) are added. Phosphorus dynamics in the soils are complex, because they involve both chemical and biological processes and the long-term effects of sorption (fixation) and desorption (release) processes (Bationo and Kumar, 2002). Both types of P fertilizer (RP and SP) are directly applied to the soil. Lukiwati (1999) reported that SP produced significantly higher maize grain yield and DM yield of stover than those that received application of rock phosphate. According to Jones (1990), the response obtained to applications of P fertilizers will be a function of many factors i.e., the initial availability of soil P, the pasture species used, the form of fertilizer applied, and the presence or absence of effective mycorrhizae fungi in the soil.

Rock phosphate as one of the phosphorus sources, its price is relatively cheaper than superphosphate and it is available in fast amount in Indonesia. However, RP belongs to slow available source of phosphorus. The residual effect of RP and SP fertilization was not significantly different on the maize grain yield and DM yield of maize stover (Lukiwati and Waluyanti, 2001).

Different management practice is adopted to increase and optimize the maize yields. For example, use of organic manures alongside inorganic fertilizers often lead to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity (CEC) and soil's biological activity (Saha *et al.*, 2008).

4. ORGANIC PHOSPHORUS ENRICHED MANURE

Manure enriched with RP show better agronomic efficiency than di-ammonium phosphate (DAP) when applied on equal P_2O_5 basis (Sekhar *et al.*, 2008). In the first season planting of sweet corn, RP (66kg P/ha) enriched manure (20 t/ha) and inoculated with biodecomposer (EM4, stardec, startmic) depend on the treatment, and that was called manure plus applied in the vertisol soil. The result showed that RP enriched manure with or without biodecomposer, in granular or non-granular form, resulted in similar on crude protein (CP), P and Ca concentration of sweet corn stover (Table 1) (Lukiwati *et al.*, 2015).

Table 1. Nutrient concentration of sweet corn stover in the first planting season (%) (Lukiwati *et al.*, 2015)

Treatments	CP	P	Ca
Manure	5.70	0.56	0.19
Manure + EM4	6.69	0.48	0.30
Manure + Stardec	6.84	0.51	0.18
Manure+ StartMik	6.74	0.55	0.17
Granular manure+EM4	7.11	0.47	0.20
Ganular manure+Stardec	5.70	0.43	0.24
Granular manure+Startmik	6.44	0.39	0.25

Residual effect of manure plus inoculated with biodecomposer resulted in similar on crude protein concentration, and higher on P and Ca concentration of sweet corn stover compared to manure without biodecomposer. Residual effects of application rock phosphate enriched manure can be used for the next growing season of second planting (Lukiwati and Pujaningsih, 2015).

Table 2. Nutrient concentration of sweet corn stover in the second planting season (%) (Lukiwati and Pujaningsih, 2015)

Treatments	CP	P	Ca
Manure	8.72	0.24	0.27
Manure + EM4	8.73	0.33	0.36
Manure + Stardec	8.94	0.33	0.40
Manure+ StartMik	8.33	0.38	0.39
Granular manure+EM4	6.06	0.38	0.53
Ganular manure+Stardec	8.47	0.37	0.54
Granular manure+Startmik	8.64	0.43	0.45

Table 3. Calsium and phosphorus concentration of sweet corn stover in the third season of planting (%) (Lukiwati *et al.*, 2017)

Treatments	Ca	P
Manure	0.17	0.37
Manure + EM4	0.24	0.42
Manure + Stardec	0.17	0.41
Manure+ StartMik	0.19	0.40
Granular manure+EM4	0.24	0.50
Ganular manure+Stardec	0.21	0.48
Granular manure+Startmik	0.24	0.44

Mineral concentration (Ca and P) of sweet corn stover at the third season of planting resulted in higher if inoculated with biodecomposer compared to without biodecomposer. Table 3 showed mineral concentration of sweet corn stover in the third season of planting (Lukiwati *et al.*, 2017).

5. ORGANIC NITROGEN AND PHOSPHORUS ENRICHED MANURE

Nitrogen and phosphorus as a major plant nutrient and the primary factors limiting crops yield (Zaidi *et al.*, 2009). Therefore, application of N and P fertilizers is essentially required to improve crop yield. 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. Manure in general low in most of major nutrient, and organic nitrogen (N-legume) and organic phosphorus (RP, guano) can advantageously compensate the imbalance of manure on N and P nutrients (Ramilison, 2001. Application of organic fertilizers with the addition of inorganic fertilizers, increased soil fertility and crop production also saved the use of inorganic fertilizers (Saha *et al.*, 2013). 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. Lukiwati *et al.*, (2018) reported that organic-NP enriched manure which added 200kg N/ha (*Gliricidea sepium*) and organic phosphorus 66kg P/ha (RP, guano) and all plot was added 125 K/ha (KCl) resulted in similar on CP (crude protein) and Ca uptake of sweet corn stover (Table 4). Organic-N (N-legume) and organic-P (RP, guano) and organic-NP enriched manure resulted in similar on CP and Ca uptake of stover compared to inorganic fertilizer (TSP+SA). Application of organic-NP enriched manure could be a promising organic fertilizer to replace inorganic fertilizer (TSP, SA) to produce sweet corn in vertisol soil.

Tabel 4. Calsium and CP uptake of sweet corn stover in the first season of planting (g/plot) (Lukiwati et al., 2018)

Treatments	CP uptake	Ca
TSP	380.50	16.02
Sulphate acid (SA)	631.62	25.11
TSP+SA	584.42	25.48
Manure	402.53	19.97
Manure+RP	445.84	20.11
Manure+guano	483.07	24.20
Manure+ *G. sepium*	422.10	27.70
Manure+RP+*G. sepium*	415.39	24.37
Manure+guano+*G.sepium*	486.75	29.32

Lukiwati *et al.* (2019) reported that fresh waxy corn (sticky maize) stover production and fresh cornhusk production significantly affected by the manure plus treatment (organic-NP enriched manure). Manure plus resulted in similar on fresh waxy corn stover production and fresh cornhusk production compared to inorganic-NP fertilizer. It was concluded that organic-NP enriched manure replaces NPK as inorganic fertilizer (Table 5).

Table 5. Fresh production of stover and cornhusk of waxy corn with manure plus and inorganic fertilization in the first season of planting (kg/plot) (Lukiwati et al., 2019)

Treatments	Fresh stover production	Fresh corn-husk production
SA+TSP+KCl	24.50	4.30
Manure	17.90	6.30
Manure+RP	19.30	5.60
Manure+guano	21.40	3.80
Manure+*G. sepium*	23.40	4.40
Manure+RP+*G. sepium*	25.50	4.00
Manure+guano+*G.sepium*	27.30	4.20

REFERENCES

1. **Abdullah L.** (2009). Growth pattern of creeping signalgrass (*Brachiaria humidicola*) in pasture fertilized with different nutrient sources. J. Anim. Sci. Tech., **32**: 71-80.
2. **Bationo A. and Kumar A.K.** (2002). Phosphorus use efficiency as related to sources of P fertilizers, rainfall, soil, crop management, and genotypes in the West African semiarid tropics. Proc. of Food Security in Nutrient-Stressed Environments. Kluwer Academic Publishers, Pp. 145-54.
3. **Coffey L. and Mumma T.** (2014). Integrating Livestock and Crops: Improving soil, solving problem, increasing income. ATTRA Sustainable Agriculture. 1-800-346-9140, www.attra.ncat.org.
4. **Edmeades D.C.** (2003). The long-term effects of manures and fertilizers on soil productivity and quality: a review. Nutrient Cycling in Agroecosystems, **66**: 165-80.
5. **Gupta V., P.K. Rai and K.S. Risam** (2012). Integrated crop-livestock farming systems: A strategy for resource conservation and environmental sustainability. Ind. Res. J. Ex. Edu. Spe. Issue, **2**: 49-54.
6. **Jones R.J.** (1990). Phosphorus and beef production in northern Australia. I. Phosphorus and pasture productivity. Trop. Grassld., **24**: 131-39.
7. **Kerridge P.C. and Ratcliff D.** (1982). Comparative growth of four tropical pasture legumes and guinea grass with different phosphorus sources. Trop. Grassld., **16**(1): 33-40.
8. **Liu T., L.F. Rodrigues, A.R. Green, D.W. Shike, J.R. Segers, G.M. Maia and H.D. Norris** (2012). Assessment of cattle impacts on soil characteristics in integrated crop-livestock systems. Am. Soc. Agric. Biol. Eng. Annu. Int. Meeting, **7004**(12): 3514-21.
9. **Lukiwati D.R. and Waluyanti R.** (2001). Response of maize to the residual effect of phosphorus fertilization in latosolic soil. In: Kovacevic V. (Ed.). Collection of Summaries. 37th Croatian Symposium on Agriculture with an International Participation. Opatija, February 19-23. Pp.183.
10. **Lukiwati D.R.** (2002). Effect of rock phosphate and superphosphate fertilizer on the productivity of maize var. bisma. In: Food Security in Nutrient-Stressed Environments: Exploiting Plants' Genetic Capabilities. Kluwer Academic Publishers. London, J.J. Adu-Gyamfi (Ed.), Pp. 183-87.
11. **Lukiwati D.R.** (2007). Dry matter and digestibility improvement of *Centrosema pubescens* and *Pueraria phaseoloides* with rock phosphate fertilizer and VAM inoculation. Indonesian J. Agr. Sci., **9**(1): 1-5.
12. **Lukiwati D.R., Purbayanti E.D. and Pujaningsih R.I.** (2015). Natural phosphorus enriched manure in granular form and inoculated with biodecomposer to enhance *Zea mays saccharata* stover nutrient as local forage in dry land. J. Trop. Forage Sci., **5**(1): 42-45.
13. **Lukiwati D.R. and Pujaningsih R.I.** (2015). Residual effect of phosphate rock enriched manure in granular form and biodecomposer inoculation on sweet corn stover nutrition in dryland. J. Tro. For. Sci., **4**(2): 78-82.
14. **Lukiwati D.R., Purbayanti E.D. and Pujaningsih R.I.** (2017). Effect of manure plus on sweet corn production and mineral concentration of stover on three season of planting. J. Tro. For. Sci., 7(1): 17-21.
15. **Lukiwati D.R., Kusmiyati F. and Herwibowo B.** (2018). Effect of manure plus and inorganic fertilizer on maize production and nutrient uptake in Central Java Indonesia. Proc. of the 5th Int. Con. Agr. Colombo, **1**: 1-6.
16. **Lukiwati D.R., Pujaningsih R.I. and Murwani R.** (2018). The effect of organic phosphorus and nitrogen enriched manure on nutritive value of sweet corn stover. IOP Conf. Ser.: Earth Environ. Sci., **119**: 1-7.
17. **Lukiwati D.R., Kusmiyati F., Yafizham and Anwar S.** (2019). Improvement of plant growth and production of waxy corn with organic-NP enriched manure and inorganic fertilizer in Sragen District of Central Java

Indonesia. IOP Conf. Series: Earth Env. Sci., **292**: 1-6.

18. **Mariyono J.** (2014). The economic of Indonesian rice-based agribusiness. International J. Adm. Sci. Org., **21**(1): 35-43.
19. **Moraine M., Duru M. Nicolas P., Leterme P. and Therond O.** (2014). Farming system design for innovative crop-Livestock integration in Europe. Animal, **8**(8): 1204-17.
20. **Nassir A.** (2001). IMPHOS Experience on direct application of phosphate rock in Asia. In:Rajan SSS and Chien SH (Eds.) Proceedings of an International Meeting Direct Application of Phosphate Rock and Related Appropriate Technology - Latest Developments and Practical Experiences. Kuala Lumpur, July 16-20, Pp 110-22.
21. **Nimwegen P.V., Lloyd D. and Vanclay J.** (2009). Prospects for integrated timber-forage-livestock agroforestry systems for economic diversification in West Timor farming communities. Final Report. ACIAR.
22. **Ramansyah M., N. Hidayati, T. Juhaeti and A. Sugiharto** (2013). Effect of bio-organic fertilizer on productivity improvement of well adapted local maize (*Zea mays ceratina* L.) variety. ARPN J. Agric. Biol. Sci., **8**(3): 233-40.
23. **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, Pp 394-98.
24. **Saha S., Mina B.L., Gopinath K.A., Kundu S. and Gupta H.S.** (2008). Organic amendments affect biochemical properties of a subtemperate soil of the Indian Himalayas. Nutr.Cycl. Agroecosys. **80**: 233-42.
25. **Saha R., Saieed M.A.U. and Chowdhury M.A.K.** (2013). Growth and yield of rice (*Oriza sativa*) as influenced by humic acid

    and poultry manure universal. J. Plant. Sci, **1**: 78-85.
26. **Sekhar D.M.R., Dassin Y., Momani L. and Hamatteh A.** (2008). Phosphate rich organic manure as fertilizer. https:www.researchgate.net/publication/36789665. Sitated 17 September 2017.
27. **Singh H. and ReddyM.S.** (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**: 30-36.
28. **Silva P.S.L., Duarte S.R., Oliveira F.H.T. and Silva J.C.V.** (2007). Effect of planting density on green ear yield of maize cultivars breed in different periods. Horticultura Brasileira, **25**: 154-58.
29. **Soelaiman Y. and Maswar** (2014). Integration of crop-livetock-biogas and the effect of dried sludge manure on the growth and yield of maize on ultisol soil. Agrivita, **36**(2): 160-68.
30. **Syuaib M.F.** (2016). Sustainable agriculture in Indonesia: Facts and challenges to keep growing in harmony with environment. AgricEngInt: CIGR Journal Open Access, **18**(2): 170-84. at http://www.cigrjournal.org.
31. **Winks L.** (1990). Phosphorus and beef production in Northern Australia. 2. Responses to phosphorus by ruminants – a review. Trop. Grassld., **24**: 140-58.
32. **Witjaksono J., Suharyanto and Indrasti R.** (2018). Developing integrated crop-livestock farming system as a strategy for growth in low income countries: A Brief Review. Anim. Vet. Sci., **6**(1): 12-16.