Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 21, No. (2) : 2019 : 92-98

ISSN-0972-3005

POTENTIAL GROWTH, PRODUCTION AND NUTRITION CONTENT OF INDIGOFERA ZOLLINGERIANA PLANTSUNDER THE OIL PALM PLANTATION STAND IN BOGOR, INDONESIA

SAIJO[1], SUDRADJAT[2*], Y. SUDIRMAN[2] AND Y. HIDAYAT[3]

[1]Study Program of Agrotechnology Faculty of Agriculture and Forestry
Muhammadiyah University of Palangkaraya, 733111, Indonesia. email: saijo_12@yahoo.com
[2]Department of Agronomy and horticulture, Faculty of Agriculture, Bogor Agricultural University, Darmaga, Bogor, Indonesia 16680.
[3]Department of Soil Science and Land Resources, The Faculty of Agriculture IPB, Darmaga, Bogor Indonesia 16680

(Received 2 September, 2018; accepted 30October, 2018)

Key words : *Indigofera, Livestock feed, EFB, nutrition.*

Abstract – *Indigofera zollingeriana* has a huge potential as an alternative livestock feed and this plant is able to grow under low-intensity light conditions. The purpose of this study was to determine the relationship between the growth potential and nutritional content of the plant *I. zollingeriana* planted in palm plantation stacking rows (5 years old).This study was designed using a randomized groups design. The treatments consisted of two factors: the *Indigofera* treated with oil palm empty fruit bunches (EFB) (I+T) and *Indigofera* without EFB (I). The treatments were repeated in triplicate and six experiment units. The variables observed were the morphology (plant height, number of branches, and trunk diameter), production (fresh and dried biomass per plant), and nutritional content (crude protein, crude fat, crude fiber, and gross energy). The results of the study revealed that oil palm empty fruit bunches had a significant effect on the plant height (cm), trunk diameter (cm), and number of branches at I+T (303.7±24.5 cm/plant), I+T (5.38.±0.06 cm/plant), I+T (73.6±11.3 branches/plant), respectively. The content percentage for crude protein, crude fiber, and crude fat in plants treated with oil palm empty fruit bunches were, respectively, 11.07 %, 2.12%, and 9.97%. It can be concluded that all the growth variables, namely height, diameter, and the number of branches varied. Plant height, number of branches, and the trunk diameter were influenced by the EFB treatment and oil palm canopy shade. *I.zollingeriana* can be cultivated under oil palm stand with the oil palm empty fruit bunch treatment and would grow to be more productive and have a high nutritional content.

INTRODUCTION

Development of non-fodder foragegrass one of the efforts improve the quality of animal feed in the tropis area like Indonesia. This condition is very necessary, because of the supply of nutrients needed by livestock from grass is very limited and is strongly influenced by environmental conditions as; season, weather, radiation intensity, and ainfall. Part of it big livestock productivity in Indonesia will decrease when supply and quality of grass limited especially during the dry season. This is getting worse due to= Nutrient content, especially protein in natural grass is very limited compared other plants his. Development of high nutritional forages such as Indigofera zollingeriana expected to be able to meet the nutritional needs of livestock even though dry season.

Globally, livestock derive fodder from two-thirds (4.9 Bha) of all agricultural areas, comprising 3.4 Bha of grazing land and one-quarter of the area sown to crops (Foley *et al*., 2011). The world has 17 billion livestock (mainly cattle including buffaloes, sheep, goats, pigs and chickens, but also including lesser-known species such as guinea fowl, yaks and camels, which are important in some areas). Livestock, especially ruminants, have the ability to convert low-quality biomass into high-quality nutrient-dense foods (Smith, *et al*., 2013a), In oil palm plantations there is space that has not been

***Corresponding author's email:** sudradjat_ipb@yahoo.com

well-utilized, the stacking rows. Five-year-old oil palms have fairly wide canopies which cause the shade level and soil moisture level to be quite high. Therefore, livestock fodder plants such as indigofera are a good choice for cultivation. Hassen *et al.* (2007) reported that indigofera is classified as a plant which can tolerate shade and has a high nutritional content. In addition, the ecological distribution of indigofera is quite wide. The study by Hassen, *et al.* (2008) revealed that indigofera grows well under full light conditions, but is tolerant to shade, drought, pooled water, acidic soil, and salinity.

This study specifically used *Indigofera zollingeriana* which is a species of indigofera. The superiority of the species *I. zollingeriana* is its high nutritional content. That indigofera is a type of legume that contains crude protein and energy is high enough and commonly used to feed ruminants especially goats, sheep and cattle (Tarigan and Ginting, 2011). Even though its nutritional content as livestock feed raw material is high, farmers have rarely utilized this plant. Abdullah and Suharlina (2010) believed that this phenomenon is due to the lack of materials and the fact that it is not yet produced on a wide scale.

The greatest amount of waste produced by oil palms is in the form of oil palm empty fruit bunches which contributes between 30-35% of the weight of fresh fruit bunches in every harvest. Oil palm empty fruit bunches can be used as an alternative organic fertilizer. Utilizing them as a fertilizer could be a solution for improving a more sustainable oil palm industry management (Yahya *et al*., 2010; Yoshizaki *et al*., 2013). The utilization of oil palm empty fruit bunches as a soil improver and a source of soil nutrients could be done by direct application as mulch or by composting. Tao, *et al*., 2018 revealed that EFB application has a high potential to enhance soil biota and functions in oil palm plantations. The purpose of this study was to determine the relationship between the growth potential and the nutritional content of the plant *I. zollingeriana* planted in oil palm plantation stacking rows (5 years old).

MATERIALS AND METHODS

Time and Location

This study was conducted between January 2017 and May 2017 at the IPB-Cargill Oil Palm Education and Research Plantation, Jonggol Sub-district, Bogor Regency, West Java.

Experimental Design

The land used was the stacking rows beneath oil palm stands sized 45 m x 8 m. The experimental plots were made by first clearing out the weeds, other vegetation, and trash from around the area. Oil palm empty fruit bunches as the treatment were applied directly to the land at a dose of 30 t ha^{-1} (1300 kg/study plot) by arranging them evenly in the designated stacking row experimental plots. Planting holes sized 20 cm x cm x 25 cm (length x width x height) were made. Manure (sheep dung) as a base fertilizer was applied at a dose of 2 kg per planting hole a week prior to planting. The seedlings planted were aged 5 months post-sowing.

There were two treatments: indigofera planted with the application of oil palm empty fruit bunches (I+T) andindigofera planted without the application of oil palm empty fruit bunches (I). Each treatment was repeated in triplicate, resulting in 6 units of experimental plots which had 9 samples collected per experimental plot. The planting distance was 1 m x 1.5 m with a plant population of 300 plants per experimental plot.

Parameter measured

Plant height, number of branch and stem diameter. The height of the plants was measured from the base of the trunk to the tip of the canopy using a measuring stick, the diameter of the trunk was measured using a Vernier caliper by clamping the trunk 10 cm from the base. The diameter measurements were taken 10 cm above the soil surface by clamping the plant trunk using a Vernier caliper. The jaw of the caliper was then pushed until it no longer moved and the diameter shown on the caliper's display screen was recorded. The trunks that have been measured were then marked with paint for the next measurement. The number of branches was counted manually and each marked afterward so that it would not be counted again during the next observation.

The indigofera seedlings were planted 5 months after being sown (Figure 1). This was done so that the seedlings would not experience stress in their growing environment due to the transplant. The plants were cared for and observed throughout the duration of the study (Figure 2). After the plants reached 6 months of age, the canopies were trimmed to collect wet weight, dry weight, and nutritional content samples.

Wet weight and dry weight. Thewet and dry weights of the canopy were measured by trimming

Fig. 1. Indigofera seedlings aged 5 months

Fig. 2. Indigofera forage after 6 months planting

three sample trees. The leaves were dried in an oven at a temperature of 60°C for 48 four h (Solati *et al*., 2016). The three plant samples were then combined and weighed using a Mettler digital balance with a 3000 g capacity as the canopy dry weight.

Nutritional content: Harvesting was done by cutting off the plant canopy and separating the leaves and branches to be oven dried at 65°C for 72 hours for the proximate analysis. The samples were ground using a Hummer mill with a 1.0 mm mesh sieve. The moisture, ash, crude fiber, and fat were determined using the standard method of Analytical Chemical Association (AOAC, 2005).

Statistical analysis

The data obtained were analyzed using the Analysis of Variance according to Steel and Torrie (1993). The analysis used the Minitab (version 18) statistical package. If the results were significantly different, it was followed up using a t-test at $\alpha = 5\%$.

RESULTS AND DISCUSSIONS

Indigofera zollingeriana Growth

Based on the 5% level t-test, it the height variable for the plant *I. zollingeriana* planted in 5-year-old oil palm stacking rows treated with oil palm empty fruit bunches was significantly higher statistically than that of the plants not treated with oil palm empty fruit bunches. The trunk diameter variable demonstrated a larger diameter for *I. zollingeriana* plants planted in stacking rows treated with oil palm empty fruit bunches than plant not treated with oil palm empty fruit bunches. Similar results were demonstrated by the branch number variable. There were more branches on plants treated with oil palm empty fruit bunches. The average morphological data (plant height, trunk diameter, and the number of branches) for *I. zollingeriana* for each of the treatments are presented in Table 1.

The results of the study conducted demonstrated that all the *Indigofera zollingeriana* growth parameters were higher in the plants treated with EFB

Table 1. Efect of treatment of empty fruit bunches or morphologcal variables of plant *I. zollingeriana* in February 2017–Mey 2017.

Month	Plant height (cm)		Stem diameter (cm)		Number of bunches (fruit)	
	I + T	I	I + T	I	I + T	I
Feb.	66.48±9.29	147.6±18.20	2.29±0.07	2.28±0.06	29.81±2.76	28.22±1.25
March	205.33±7.21	193.19±9.57	4.04±0.89	2.83±0.13	31.78 ±4.48	27.96± 6.61
April	250.4±16.20	234.15±9.92	4.31±0.03	3.25±0.04	37.70± 6.54	27.15±3.09
May	303.7±24.50	280.3±20.40	5.38±0.06	4.27±0.05	73.6±11.30	45.81±7.76
Notasi	February^{ns} March – May*		February^{ns} March* April – May**		February – March^{ns} April – Meay**	

Description: I + T = *Indigo* + EFB, I = *Indigo*,^{ns} = not significantly (á 0.05)* = significantly based on t-test at level á = 5%.

compared to those in plants not treated with EFB. The plant height parameter showed that the plants reached a height of 303.7 cm in 5 months, or grew 60.74 cm/month. A study of 5 types of legumes conducted by Dhaulakhandi *et al*., 1995 discovered that *Cicer arietinum*, *Pisum sativum*, *Vigna sinensis*, *Phaseolus aureus*, and *Dolichos lablab* had lower height increases, 39.36 cm, 14.8 cm, 21.44 cm, 11.2 cm, and 7.6 cm/month, respectively.

The study results demonstrated that the growth was higher than that of other legumes. The largest trunk diameter in this study in 5 months was 5.38 cm or 1.08 cm/month growth. The observation results demonstrated that plants under the canopy had longer trunks, wider and thinner leaves, and a lower leaf weight. The effect of space between *I. zollingeriana* plants is presented in Table 1. The results revealed that there was no significant difference in plant height between planting distances at the initial measurement (the first month). The difference in plant height was observed between row distances in the second to the fifth-month measurements. The results if this study demonstrated greater plant heights I+T (303.7±24.5 cm) and I (280.3 ± 20.4 cm) compared to the study conducted by Kumalasari *et al*., (2017) who reported a height of 177.15 cm.

The effect of the distance between the plant canopies on the number of branches per *I. zollingeriana* plantis presented in Table 1. A significant difference (P <0.05) between the number of branches per plant was detected between the row distances in the measurements fifth and sixth-month measurements. The highest numbers of branches per plant were recorded in I+T 73.6±11.3 and I (45.81±7.76). This result differed from Kumalasari *et al*., (2017) who reported a greater number of branches. This indicated that the number of *I. zollingeriana* leafy branches is influenced by the width of the oil palm canopy, thus resulting in a lower number of branches.

All of the growth parameters, plant height, trunk diameter, and the number of branches varied. This demonstrates that the plants were influenced by the light that penetrated the oil palm stands. Das,*et al*., (2008) wrote that the light intensity in plantations influenced the amount of light received by the vegetation growing beneath the canopy, making it a limiting factor.

Indigofera zollingeriana Production

The analysis results revealed that treatment using oil palm empty fruit bunches had a significant effect on the wet and dry weight of *I. zollingeriana* compared to the wet and dry weight of *I. zollingeriana* without the oil palm empty fruit bunch treatment. However, the t-test of the two treatments was not significantly different. The data for average dry and wet weight of *I. zollingeriana* production are presented in Figure 3.

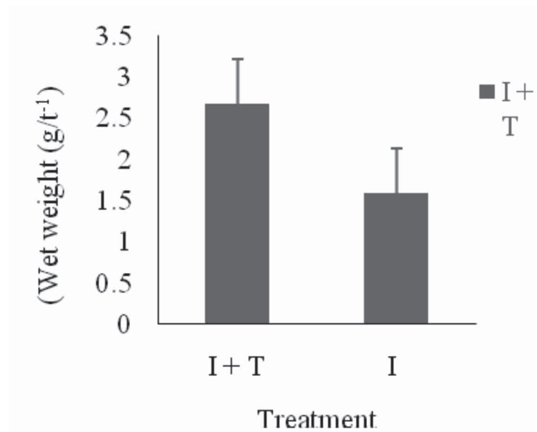

Fig. 3. Wetweight

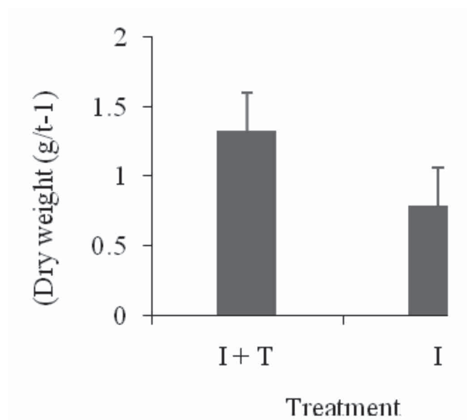

Fig. 4. Dry weight

Fig. 3 and 4. Wet and dry weight *I. zollingerina* plant canopy at harvesting of the IPB-Cargil Jonggol West Java oil palm education and research garden.

Production of dry materials, including leaves and branches which can be consumed by livestock, can be seen in Table 2. In proportion to the increase in the plant height and trunk diameter, the EFB treatment had a significant effect (P< 0.05) on the dry weight of the plant parts that could be consumed. The planting distance on the land used causes competition for nutrient and light utilization. The intensity of light penetrating the oil palm canopy became lower, affecting the production of dry material by plants growing beneath it.

Table 2. Protein content, crude fat, crude fiber and gross energy due to the influence of the treatment of oil palm empty furit in *I. zollingeriana.*

Proximate	Treatment	
	I + T	I
Crude protein (%)	11.07±0.39[a]	10.44±0.31[b]
Crude fat (%)	2.12±0.55[a]	1.65±0.06[a]
Crude fiber (%)	9.97±1.27[a]	8.59±0.55[a]
Gross energy (kkal/g)	4393.3±43.09[a]	4326.66±15.30[b]

Description: I + T = *Indigo* + EFB, I = *Indigo*,[ns] = not significantly (α 0.05)* = significantly based on t-test at level α = 5%.

Low production in densely grown plants could be due to the shade which reduced the leaf ratio. Dý'az-Pe'rez, (2013) reported that the dry weight of the canopy differed at different shade levels. That was also because the canopy of *I. zollingeriana* growing beneath the oil palm canopy changed morphologically, the leaves becoming smaller in size and lighter in weight. This study reported that plants growing under a canopy would demonstrate adaptive responses. Shehu *et al.,* (2011) declared that the leaf ratio is very important because leaves are a part of the metabolic organ and affect the quality of legumes; a greater the number of leaves means a better quality legume. In an optimum condition, a higher plant density would increase the plant's wet and dry material productivity (Slanev and Enchev, 2014). Kumalasari *et al*., (2017) reported that the *I. zollingeriana* planted at a distance of 1 m x 0.5 m produced 3.58 kg.

The nutritional content of *Indigofera zollingeriana*

Based on the nutritional content analysis, it was revealed that nutritional content (crude protein, crude fat, crude fiber, and gross energy) of the *I. zollingeriana* plants planted in oil palm plantation stacking rows with the oil palm empty fruit bunch treatment was higher than that of plants not treated with oil palm empty fruit bunches. The data for the average nutritional content (protein, crude fat, crude fiber, and gross energy) can be seen in Table 2.

The study results revealed that the highest content was protein at 11.07±0.39% in plants treated with EFB and 10.44±0.31% in plants not treated with EFB. This protein content was higher than the results of the study by Gafar *et al.,* (2011) who reported yang that the nutritional content of *Indigofera astragalina* included fat (5.0 ± 0.5%), crude fiber (2.67 ± 0.29% DW), and crude protein (8.23 ± 0.11% DW). The higher protein content was because the study location was on a shaded oil palm plantation.

The average crude fiber content was 9.97%. According to the study by Hassen *et al*., (2006) which was conducted on open land, the crude fiber content of *I. zollingeriana* ranged between 22 and 29%. The results of the variance analysis revealed that the oil palm empty fruit bunch treatment had a very significant effect on the crude fiber content of *I. zollingeriana*.

Dewhurst *et al.,* (2009) found that the increase in gross energy of fodder was always proportionate to the increase in the crude fiber of the plant dry material. In general, livestock fodder content depends on the plant species, environmental condition and growth (soil, climate), plant fraction, and maturity level during sampling. With fairly high protein content, relatively low fiber content, and high digestibility, indigofera has potential as a source of feed and as a protein-supplement feed source (Hassen *et al*., 2007).

Environmental condition

The study results revealed that the organic-C and K contents were higher in the experiment plots treated with EFB compared to the plots not treated with EFB, whereas the N and P contents were lower (Table 3).

Table 3. Nutrient analysis in the Jonggol-IPB Bogor West Java oil palm education and research field.

Treatment	Variable			
	C-Organik (%)	N-Total (%)	P (ppm)	K (ppm)
Indigo + EFB	3.38	0.29	6.95	115.93
Indigo	2.84	0.25	6.22	80.44

The EFB treatment was expected to improve the growing environment because EFB contains various nutritional elements.

Research by Singh *et al*., (1989) revealed that the percentage of EFB to FFB is around 20% and every ton of empty fruit bunches contains nutrients N, P, K and Mg, which is equivalent to 3 Kg of Urea; 0.6 Kg CIRP; 12 Kg MOP; and 2 Kg Kieserit also reported by Baharudin *et al*., 2010 that 42% C contained EFB, 0.8% 0.06% of N, P, K and 0.2% 2.4% Mg.

This finding was supported by Yahya *et al*., (2010) revealed that EFB was also found to hold its water more strongly. Due to these nutrients, oil palm empty fruit bunch do not only have not potential as a source of organic materials but can also be used as a soil improver. The high phosphorous content means that it is highly suitable for legumes. Phosphorous plays a role in improving root development and is a source of energy through ATP formation (Shaheen *et al.*, 2007). Legumes require a large amount of phosphorous for nodulation and nitrogen fixation.

Corley and Thinker, (2003) stated that the application of EFB could increase the soil pH and cation exchange capacity. Siddiqueea *et al*., 2017 reported the highest nitrogen (N), phosphorous (P), and potassium (K) ratio was found to be 0.46: 0.83: 5.85. The soil condition in this study had some similarities with that in the study conducted by Hamdan *et al*., 2006 who stated that the soil condition before treatment with EFB had low soil quality content, C = 0.43%, N = 0.05%, K = 0.23% and P= 12.77 mg kg^{-1}.

The Relationship between Environmental Conditions and Indigofera

EFB utilized as mulch on plantations can be used to control weeds, maintain humidity, and prevent soil erosion (Alam *et al*., 2009; Misson *et al*., 2009). EFB can also be used as a soil improver to increase input production in the oil palm cultivation system. Indigofera needs a number of nutrients during its growth and development period growth and these can be fulfilled by the nutrients contained by EFB. Therefore, fertilizing can support plant nutrient availability and balance (Sudradjat *et al*., 2014). The fulfillment of nutrients needed by indigofera plants would improve the nutritional content of this fodder (Vendramini *et al*., 2007).

CONCLUSION

Based on thestudy that had been conducted, it can be concluded that all the growth variables which were height, diameter, and the number of branches, varied. Plant height, number of branches, and trunk diameter were influenced by the EFB treatment and oil palm canopy shade. *I. zollingeriana* can be cultivated under oil palm stands with oil palm empty fruit bunch treatment and it grows more productively and has a high nutritional content.

ACKNOWLEDGMENTS

The author would like to thank the Director of Research and Community Services, Directorate General of Research Strengthening and Development, Ministry of Research, Technology, and Higher Education, which in accordance with the Doctoral Dissertation Research Contract 2018 Financial Year Contract number 115/SP2H/LT/DRPM/2018, had provided the funds for this research so that this study could be concluded within the predetermined time limit.

REFERENCES

Abdullah, L. and Suharlina, 2010. Herbage yield and quality of two vegetative parts of Indigofera at different times of first regrowth defoliation. *Med. Pet.* 3(1) : 44–49.

AOAC, 2005. Official Methods of Analysis 18th edition. AOAC. International, Arlington, VA, USA.

Baharuddin, A.S, Hock, L.S., Yusof, M.Z., Abdul Rahman, N.A., Md Shah, U.K., Hassan, M.A., M.K.Wakisaka., Sakai and Shirai, Y. 2010. Effects of palm oil mill effluent (POME) anaerobic sludge from 500 m^3 of closed anaerobic methane digested tank on pressed-shredded empty fruit bunch (EFB) composting process. *African Journal of Biotechnology.* 9(16) : 2427-2436.

Corley, R.H.V. and Tinker, P.B. 2003. The Oil Palm (Fourth Edition). Blackwell Science ltd., Oxford. P:562.

Das, D.K., Chaturvedi, O.P., Mandal, M.P., Kumar, R. 2008. Effect of tree plantations on biomass and primary productivity of herbaceous vegetation in eastern India. *Trop Ecol.* 49 : 95–101.

Dewhurst, R.J., Delaby, L., Moloney, A., Boland, T. and Lewis, E. 2009. Nutritive value of forage legumes used for grazing and silage. *Irish J Agric Food Res.* 48: 167–187.

Dhaulakhandi, A.B., Joshi, R.P. and Joshi, M.C. 1995. A study on Growth and Development of Five Leguminous Plant Species tin Antarctic soil, During Polar Day, Scientific Report of Xth Indian Scientific Expedition to Antarctica, Department of Ocean Development, Govt. of India, New Delhi, Technical Publication No.8, 209-217.

Dýaz-Perez, J.C. 2013. Bell pepper (*Capsicum annum* L.) Crop as affected by shade level: microenvironment, plant growth, leaf gas exchange, and leaf mineral nutrient concentration. *Hort. Science.* 48 : 175–182.

Foley, J.A.; Ramankutty, Brauman, N., Cassidy, K.A., Gerber, E.S., Johnston, J.S., Mueller., ND, M., O'Connell C; Ray, D.K., West, P.C., Balzer, C., Bennett, E.M., Carpenter, S.R. Hill J; Monfreda C; Polasky S; Rockstrom J; Sheehan J; Siebert S; Tilman D; Zaks DPM. 2011. Solutions for a cultivated planet. *Nature.* 478 : 337–342.

Gafar M.K., Itodo A.U., Atiku, F.A., Hassan, A.M. and Peni, I.J. 2011. Prokximate and Mineral Compostion of the leaves of Hairy indigo (*Indigo astragalina*). *Pakistan Journal of Nutrition.* 10 (2): 168–175.

Hamdan, A.B., Mohd Tayeb, D. and Ahmad, T.M. 2006. Effects of empaty fruit bunch application in oil palm on a bris soil. *Oil Palm Bul.* 52 : 48 – 58.

Hassen A, N.F.G., Rethman, W.A.Z. Apostolides and van Niekerk, W.A. 2008. Forage production and potential nutritive value of 24 shrubby Indigofera accessions under field conditions in South Africa. *Trop. Grasslands.* 42:96 –103.

Hassen A, W.A., Van Niekerk, N.F.G., Rethman and Tjelele, T.J. 2006. Intake and in vivo digestibility of indigofera forage compared to medicago sativa and leucaena leucocephala by sheep. *South African J.I Anim.* 36: 67–70.

Hassen, A., N.F.G., Rethman, Van Niekerk., Tjelele, T.J. 2007. Influence of season/year and species on chemical composition and in vitrodigestibility of five Indigofera accession. *J. Anim Feed Sci Technol.* 136 : 312– 322.

Kumalasari, N.R., Wicaksono, G.P. and Abdullah, L. 2017. Plant Growth Pattern, Forage Yield, and Quality of *Indigofera zollingeriana* Influenced by Row Spacing. *Med. Ped.* 40(1) : 14–19.

Misson, M., R. M.F.A., Haron, Kamaroddin and Amin, N.A.S. 2009. Pretreatment of empty palm fruit bunch for production of chemicals viacatalytic pyrolysis. *Biores. Technol.* 100 : 2867–2873.

Nsiaha, S.A., Ahiakpab, J.K. and G. Asamoah-Asantec, 2018 Productivity of pigeonpea genotypes as inuenced by palm bunch ash and NPK fertiliser application. *Annals of Agricultural Sciences.* pp. 83–89

Shaheen, A.M., Mouty, M.M.A,. Ali, A.H. and Rizk, F.A. 2007. Natural and chemical phosphorus fertilizers asaffected onion plant growth, bulbs yield and its some physical and chemical properties. *Austral. J. Basic Appl. Sci.* 1 : 519-524.

Shehu, Y., Al-Hassan, W.S., Pal, U.R. and Philips, C.S.J. 2001. Yield and chemical composition response of Lablab purpureus to nitrogen, phosphorus and potassium fertilizers. *Trop Grassl.* 35 : 180-185.

Siddiquee, S., Shafawatia, S.N. and Naher, L. 2017. Effective composting of empty fruit bunches using potential *Trichoderma strains*. *Biotechnology Reports.* 13 : 1–7.

Singh, G., Manoharan, S. and Toh, T.S. 1989. United plantations approach to palm oil mill by product management and utilization. Proceedings of International Palm Oil Development Conference, Palm Oil Research Institute of Malaysia, Kuala Lumpur, 225 –234.

Slanev, K. and Enchev, S. 2014. Influence of veriety and density on crop productivity of sorgum X sudan grass hybrids in flowering stage. *BJAS.* 20(1) : 182 – 185.

Smith, J., Sones, K., Grace, D., MacMillan, S., Tarawali, S. and Herrero, M. 2013a. Beyond milk, meat, and eggs: Role of livestock in food and nutrition security. *Animal Frontiers.* 3 : 6-13.

Solati, Z., Jørgensena, U., Eriksen, J., Søegarda, K. 2016. Dry matter yield, chemical compostion and estimated extraktable protein of legume and grass species during the spring growth. Proceedings of the 26th European Grassland Federation (EGF) general meeting. "The Multiple Roles of Grassland in the European Bioeconomy". 5–8 September 2016

Steel, Robert. G.D. and James Torrie, 1993. Principles and Procedures of Statistics – A Biometrical Approach. McGraw-Hill Book Company. New York.

Sudradjat, A., Darwis, A. and Wachjar, 2014. Optimizing of nitrogen and phosphorus rates for oil palm (*Elaeis guineensis* jacq.) seedling in the main nursery. *Jurnal Agronomi Indonesia.* 42(3) : 222–227.

Tao, H.H., Jake, L., Snaddonb, Eleanor M. Sladea, C, Ludovic Hennerond, Jean-Pierre Calimane, Katherine J. Willisa, 2018. Application of oil palm empty fruit bunch effects on soil biota and functions: A case study in Sumatra, Indonesia. *Agriculture, Ecosystems & Environment.* 256 : 105-113.

Tarigan, A. and Ginting, S.P. 2011. The effect of *Indigofera* sp and *Brachiaria ruziziensis* feeding on feed consumption and digestibility of goat. Loka Penelitian Kambing Potong PO Box 1, Galang 20855, Sumatera Utara.

Vendramini, J., M.B., M.L.A. Silveira, J.C.B. Dubeux Jr. and L.E. Sollenberger. 2007. Environmental impacts and nutrient recycling on pastures grazed by cattle. *R. Bras. Zootec.* 36 : 139-149.

Yahya, A., C.P. Sye, T.A. Ishola and. Suryanto, H. 2010. Effect of adding palm oil mill decanter cake slurry with regular turning operation on the composting process and quality of compost from oil palm empty fruit bunches. *Bioresource Technology.* 101 : 8736 – 8741.

Yoshizaki, T., Shirai, Y., Hassan M. A., Baharuddin, A.S., Abdullah, N.M.R., Sulaiman, A., Busu, Z.2013. Improved economic viability of integrated biogas energy and compost production for sustainable palm oil mill management. *Journal of Cleaner Production.* 44: 1 – 7.