

Productivity of *Indigofera zollingeriana* under Different Canopy and Soil Acidity Level in Oil Palm Estate

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ABSTRAK

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Lahan perkebunan kelapa sawit di Indonesia sangat luas dan umumnya berada pada lahan sub-optimal yang berpeluang besar bagi pengembangan peternakan dalam penyediaan hijauan pakan. Penelitian bertujuan untuk mengetahui produktivitas *Indigofera zollingeriana* pada berbagai taraf naungan. Penelitian menggunakan rancangan RAK faktorial dengan 2 taraf perlakuan yaitu 3 taraf naungan umur kelapa sawit 2, 5 dan 7 tahun dan 2 taraf kemasaman tanah yaitu netral dan masam, masing-masing perlakuan diulang sebanyak 4 kali. Peubah yang diamati adalah produksi, dan kandungan nutrisi tanaman. Hasil penelitian menunjukkan tidak terdapat interaksi antara taraf naungan kelapa sawit dengan kemasaman tanah terhadap produksi segar daun, batang/ranting, biomasa, dan nisbah daun/ranting *I. zollingeriana*. Produksi segar daun, batang, biomasa, dan nisbah daun/ranting *I. zollingeriana* sangat nyata ($P < 0,01$) menurun sejalan dengan taraf naungan. Kemasaman tanah nyata ($P < 0,05$) menurunkan produksi segar daun, batang, biomasa, dan nisbah daun/ranting. Taraf perlakuan naungan nyata ($P < 0,05$) meningkatkan kandungan protein kasar, serat kasar, dan energi, sebaliknya nilai pencernaan *in vitro* bahan kering dan bahan organik menurun. Kemasaman tanah nyata ($P < 0,05$) menurunkan kandungan kalsium, pencernaan *in vitro* bahan kering dan bahan organik *I. zollingeriana*.

Kata Kunci: *Indigofera zollingeriana*, Perkebunan Kelapa Sawit, Naungan, Tanah Masam

ABSTRACT

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Oil palm estate area in Indonesia is generally located in a sub-optimal land that has great opportunity for the development of forage supply. This study aims were to determine productivity of *Indigofera zollingeriana* under various canopy level. This research used factorial randomized block design with 3 canopy levels (under 2, 5, and 7 year oil palm canopy) and 2 levels of soil acidity (neutral and acid soil) treatments, where each treatment was repeated 4 times. Parameters observed were production and nutrient content of *Indigofera zollingeriana*. Research results showed that there was no interaction between the canopy levels and soil acidity on the production of fresh leaves, stems/branches, biomass, and leaves/stem ratio of *I. zollingeriana*. Production of fresh leaves, stems, biomass, and leaves/branches ratio of *I. zollingeriana* significantly ($P < 0.01$) decreased along with increase of canopy level. Soil acidity significantly ($P < 0.05$) decreased production of fresh leaves, stems, biomass, and leaves/branches ratio. Level of canopy treatment significantly ($P < 0.05$) increased content of crude protein, crude fiber and energy, otherwise value of *in vitro* dry matter digestibility (IVDMD) and organic matter digestibility (IVOMD) were decrease. Soil acidity significantly ($P < 0.05$) decreased calcium content, *in vitro* dry matter digestibility (IVDMD) and organic matter digestibility (IVOMD) of *I. zollingeriana*.

Kata Kunci: *Indigofera zollingeriana*, Oil Palm Estate, Canopy, Acid Soil

INTRODUCTION

Limited forage land in Indonesia is caused by several factors such as limited land availability, competition with other use, and high land conversion number. Mulyani et al. (2011) said that most of the remaining land for forthcoming agricultural development was sub-optimal or marjinal land, such as rainfed land; acidic dryland and wetland with various

biosfific issues. Atman (2006) reported that most of total area available in Indonesia (190,946,500 ha) for agriculture area were clasified as Ultisol or acidic dryland. Ultisol soil was drysoil with high abiotic stresses, such as soil pH < 4 , organic content, low cation exchange capacity, and high Mn^{2+} and reactive aluminium (Al^{3+}) element which was able to poison plant root and preventing root nodule formation in legume (Hairiah et al. 2006). Then Subagyo et al.

(2004) said that Ultisol land was more widely used for estate and protected forest area due to its high abiotic stresses. Nowadays, those lands were mostly used for oil palm estate around 5.3 million ha (CSA 2012). Therefore, oil palm estate is one of forage land resources.

Cultivation of forage in oil palm estate areal faces 2 main problems, that are low sunlight intensity and high soil acidity stresses. Light intensity under forest vegetation largely determines process of photosynthesis, botanical composition, growth, and quality of forage nutrition available for ruminant (Blair et al. 1983). As Das et al. (2008) said that forage cultivation under oil palm estate areal was restricted by low soil pH and sunlight intensity along with oil palm growth decreasing forage production. Physiologically, canopy will decrease sunlight intensity required for assimilation process of plants below. Crowder & Chheda (1982) said that decrease of incoming sunlight intensity significantly increased assimilation rate and CO₂ income decreasing quality and quantity of canopy-underneath plants. Wilson & Ludlow (1991) described that shading rate of estate plants canopy might reach 80% depending on variety of plant, plant spacing and age.

Wong & Chin (1998) said that underneath-forage production decreased along with oil palm aged. Along with oil palm aged, sunlight penetrating oil palm leaves was getting low affecting production of dry material production of the underneath plants. Chin (1998) said that dry material production of forage under nursing oil palm plant might reach 1600-2600 kg/ha and decreased to 600 kg/ha along with oil palm aged. Low transmission affected microclimate under canopy and then decreasing soil temperature. This condition might prevent growth and dry material accumulation of plants growing under oil palm trees (Abdullah 2011). Horne (1994) described that there were 2 ways to improve and increase quality and production of forage under oil palm and rubber estates. One of them was introduction of shade-tolerant forage to support its sustainable production. Therefore, technologies of cultivation in certain oil palm age and shade-tolerant forage in such specific condition were required, so that productivity of forage positively contributed to the both sides.

Based on research results conducted in a greenhouse, *I. zollingeriana* had high tolerant against acidic soil stress than *C.calothyrsus* and *G. sepium* (Herdiawan & Sutedi 2013). Subject of this study was to determine productivity of *I. zollingeriana* in acid soil condition and under oil palm canopy level to support oil palm-cattle integration.

MATERIALS AND METHODS

This study was conducted in oil palm estate in Deli Serdang district, North Sumatra by planting *I. zollingeriana* as an intercropping plant. Preparation step was conducted by sowing seed in seeding tray containing of 1 : 1 soil and compose until 4 weeks, and than moved to small polybag until 8 weeks old. Eight weeks old plants were moved to field by 2x2 m row spacing and each plot size was 8x30 m. Planting was conducted between 2, 5, and 7 years old trees in acid and neutral soil condition by administratin super dolomite (5 ton/ha). This study used factorial Randomized Block Design (Gomez and Gomes, 1984) with 3 canopy levels and 2 soil acidity levels with 4 repetitions. Based on Solarimeter, average light intensities in 2 (control), 5, and 7 years oil palm estate were 2632.90 cal/m², 1751.30 cal/m² and 698.70 cal/m², respectively. Soil acidity was assessed using pH tester and lacmus paper to soil administered by super dolomite (pH 4.72). First pruning was conducted in 60 DAP (days after planting) and then harvested 1 meter above the ground in every 90 days. Parameters observed were production of biomass, leaves, brances, ration leaves/brances and nutrients content (CP, CF, Energy, Ca, P, in vitro digestibility of dry and organic materials)

RESULTS AND DISCUSSION

Production of *I. zollingeriana*

Based on analysis of variance, there was no interaction between canopy level and soil acidity to fresh biomass production of *I. zollingeriana* (Table 1).

Table 1. Fresh biomass production of *I. zollingeriana* in various canopy levels and soil acidity (g/plant) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	6701.59	1020.00	355.11	2692.23 ^a
Acid	6645.24	92318	353.13	2640.52 ^a
Average	6673.42 ^a	971.59 ^b	354.12 ^c	

The different letters in column and row shows significant difference (P<0.01)

Table 2. Average production of fresh leaves of *I. zollingeriana* in various canopy levels and soil acidity (g/plant) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	2800.30	301.17	97.08	1066.18 ^a
Acid	2772.16	271.06	69.46	1037.56 ^b
Average	2785.23 ^a	286.12 ^b	83.27 ^c	

The different letters in column and row shows significant difference (P<0.01)

Production of fresh biomass under 2 year oil palm canopy was significantly higher by 6701.59 g/plant. The lowest production of fresh biomass was under 7 years oil palm canopy by 353.13 g/plant. Meanwhile, administration of super dolomite was not significantly different. Total production of plants and roots of all plants was influenced by canopy, where production of plants under canopy was very low followed by production of upper-part biomass (Congdon & Addison 2003). It was reported that average production of tropical forage biomass without canopy (control) was 40.11 kg/pot and decreased in 63% canopy level into 18.99 kg/pot. It sharply decreased from 76% and 84% into 7.08 and 6.27 kg/pot, respectively.

Farizaldi (2011) reported that production of forage dry material either grass and legume under 8 years oil palm trees was lower than in 5 and 3 years. This low production was caused by low light intensity due to bigger canopy shape along with oil palm aged. Batubara et al. (1999) said that older oil palm tree required more light, water and nutrient, so that its availability for underneath-plants was decrease. Average production of grass under 5-10 years oil palm trees was 10.479 ton/ha/year and increased into 14.827 ton/ha/year in 10-20 years oil palm trees. Older oil palm trees had less canopy level, so that it received more light than the 5-10 years oil palm trees. Hanafi et al. (2005) reported his research results showing that production of fresh forage planting by monoculture under 55% canopy level of oil palm was (5890.73 kg/ha) better than under 75% canopy level (5347.26 ton/ha). Production of fresh forage per m² of vegetation growing under 3 and 6 years oil palm trees was 386.54 g/m² and 189.29 g/m², respectively (Daru et al. 2014). Production of *Indigofera zollingeriana* biomass under 5 years oil palm trees was higher than native grasses under the same age of oil palm trees. Then there was a significant decrease of *Indigofera zollingeriana* production under 7 years oil palm trees.

Based on analysis of variance, there was no interaction between canopy level of oil palm and super dolomite administration to production of fresh leaves of *I. zollingeriana* (Table 2). This was in accordance with Jaramillo et al. (2010) who said that there was no

significant interaction between canopy level and limestone application to production and leaves surface area per brance.

Production of fresh leaves under 2 years oil palm trees was the highest (P<0.01) by 2800.30 g/crop. The lowest production of fresh leaves was under 7 years oil palm trees by 69.46 g/crop. Canopy level and soil acidity significantly affected production of *I. zollingeriana* fresh leaves.

Di'az-Pe'rez (2013) reported that weight of leaves, stems and upper biomass were significantly different among the canopy level treatment. It was also reported that canopy changed plant morphologically with thinner and wider leaves and lighter weight. Atwell et al. (1999) also reported that plants growing under canopy would show horizontal adaptation response and smaller chloroplast. Canopy level by 40% decreased tomato leaves weight by 24% than the plants without canopy (Bertin & Gary 1998). Then, Qifu et al. (2002) said that A1 content in high acid soil might disturb soy growth and ruined plant roots leading to low production of plant due to inefficiency of nutrient and water absorption by roots. Chen et al. (2005) said that A1 decreased CO₂ intake useful in assimilation of tangerine (*Citrus rehhni*) affecting enzyme activities involved in Calvin cycle. Nutrients supply decreased by the assimilation process disruption decreasing production and quality of plants, especially in plants sensitive to A1 stress. Hilman et al. (2004) said that in acid dry land, phosphate (P) availability was the main issue in increasing legume production.

Analysis of variance showed no interaction between canopy level of oil palm and soil acidity to production of fresh stems/branches of *I. zollingeriana* (Table 3).

The highest (3887.19 g/crop) production of fresh stems/braches was under 2 years oil palm trees and the lowest production by 270.85 g/plant was under 7 years oil palm trees. Meanwhile, administration of super dolomite was not significantly affected production of stems/branches of *I. zollingeriana*. Stems diameter shaded was thinner due to elongated growth than unshaded plants which affecting stems biomass. Larcher (1995) also said that stems diameter related to dry weight of upper plant, leaves area, and plant

Table 3. Production of fresh stems/branches of *I. zollingeriana* in various canopy levels and soil acidity (g/plant) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	3901.29	718.83	258.03	1626.05 ^a
Acid	3873.08	652.12	283.67	1602.96 ^a
Average	3887.19 ^a	685.48 ^b	270.85 ^c	

The different letters in column and row shows significant difference (P<0.01)

Table 4. Ratio of leaves/branches of *I. zollingeriana* in various canopy levels and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	0.72	0.42	0.38	0.51 ^a
Acid	0.72	0.42	0.46	0.53 ^a
Average	0.72 ^a	0.42 ^b	0.31 ^c	

The different letters in column and row shows significant difference (P<0.01)

ability to carry water from soil to leaves. Wilson & Ludlow (1991) said that morphological responses of plants under canopy such as stems extension and branching reduce might decrease dry material production due to fewer axillary buds and same leaves area. Research resulted by Kittas et al. (2012) showed that chili plant under canopy had long stems, wider and thinner leaves and low leaves weight.

Research results showed no interaction between canopy level of oil palm and soil acidity to ratio of leaves/branches of *I. zollingeriana*. Ratio of leaves/branches under 2 years was significantly (P<0.01) higher by 0.72 than under 5 and 7 years by 0.42 and 0.31, respectively. Ratio of leaves/branches in neutral and acid soil did not different (Table 4).

Shehu et al. (2001) said that ratio of leaves/branches was highly crucial since it was a metabolic organ and affected quality of legume. More leaves number showed better quality of legume. Leaves consisted highest nutrients than stems/branches. Ratio of crown/roots increased in plants under canopy due to increase of proportion of crown by sacrificing rooting system to obtain sufficient sunlight for assimilation process (Atwell et al. 1999). Allocation of resources excessively from roots to bud might lead susceptibility of plants to water stress periodically and intensive pruning. Too high root system decrease led decrease of DM production and longer recovery periode, where regrowth after defoliation related to carbohydrate and mineral reserves in root (Wilson & Ludlow 1991). Karim et al. (1991) said that increasing plant age resulted lower ratio of leaves and branches. This low ratio affected crude protein and energy content. The

most protein and energy was in branches, higher leaves ratio than branches produced higher protein and energy content which was crucial in animal productivity.

Nutrient content of *I. zollingeriana*

Based on analysis of variance, there was no interaction between oil palm canopy and soil acidity to crude protein content of *I. zollingeriana* (Table 5). Crude protein content of plants under 2 years oil palm canopy was significantly higher (P<0.05) by 26.99% than that under 5 and 7 years oil palm by 23.15% and 25.61%, respectively. Crude protein content in neutral and acid soil was not different. Daru et al. (2014) reported that crude protein content of plant under 6 years oil palm canopy was higher than that without canopy. Canopy influenced forage quality either directly or indirectly changing chemical composition. Then, Wilson & Wild (1995) said that N concentration in leaves consistently was higher under canopy than the one without canopy. Generally, there was high increase of N concentration in leaves in canopy treatment by 63% compared to the one without canopy. After all, canopy increase up to 76 and 84% was slightly increased N in leaves, but not in previous level.

N concentration of plant materials under canopy generally increased (Humphreys 2005). Congdon & Addison (2003) said that N concentration in leaves was greatly influenced by canopy, where its concentration increased in under canopy than control, but there was no significantly change in P concentration in leaves. Kephart & Buxton (1993) said that concentration of

Table 5. Crude protein content of *I. zollingeriana* in various canopy levels and soil Acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	23.94	25.20	26.83	24.99 ^a
Acid	22.35	26.01	27.14	24.48 ^a
Average	23.15 ^c	25.61 ^b	26.99 ^a	

The different letters in column and row shows significant difference (P<0.01)

Table 6. Crude fiber content of *I. zollingeriana* in various canopy levels and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	14.76	17.10	17.68	16.51 ^a
Acid	12.37	18.22	18.12	16.24 ^a
Average	13.57 ^c	17.66 ^b	17.90 ^b	

The different letters in column and row shows significant difference (P<0.05)

crude protein was much more responsive to canopy compared to other quality components. It was also said that 63% canopy might increase crude protein concentration by 26% in grass. Norton et al. (1990) said that forage grown under canopy had higher nitrogen content than forage grown on the open field. High nitrogen content was caused by canopy ease nitrogen availability in soil to be absorbed by plant and then increasing nitrogen content in plant tissue (Wilson & Ludlow 1991; Wong & Wilson 1980). Yayneshet et al. (2009) reported that crude protein content from forage in semi-arid area in Ethiopia drastically decreased which was caused by dry and soil acidity stresses. Higher structural component (NDF, ADF and ADL) content found during dry season especially in acid soil was allegedly due to high lignification and maturity stadium of plant (Hussain & Durrani 2009). Khan et al. (2008) said that overuse of organic fertilizer would damage soil structure, increase soil acidity, cause nutritional imbalance, and decrease production and quality of plant.

Based on analysis of variance, there was no interaction between oil palm canopy and soil acidity to crude fiber content of *I. zollingeriana* (Table 6). Crude fiber content under 2 years oil palm trees was significantly (P<0.05) lower by 13.57% than under 5 and 7 years oil palm treatment by 17.66 and 17.90%, respectively. Crude fiber under 5 and 7 years oil palm trees did not differ significantly. Then crude fiber content in neutral and acid soil did not show a difference. Blair et al. (1983) reported that crude protein content and cell wall consistency such as ADF and cellulose increased along with canopy density increase. Humphreys (2005) also said that canopy

would change quality of light spectrum which would be up on the leaf surface affecting in tiller and germination. Light, one of components of photosynthesis process converted carbon dioxide and water into glucose and structure carbon forming cell wall, cellulose and hemicellulose. Decrease of light intensity did not affect lignin level, however the highest lignin content was achieved in dense canopy shade (Blair et al. 1983).

There was no interaction between oil palm canopy and soil acidity to energy content of *I. zollingeriana* (Table 7). Energy content under 7 years oil palm treatment was significantly (P<0.05) higher by 4015.0 Kcal/kg than under the 2 and 5 years oil palm treatment by 3749.0 and 3895.3 Kcal/kg, respectively. Energy content in neutral was significantly lower by 3790.3 Kcal/kg than in acid soil by 3982.5 Kcal/kg. Increase of canopy level increases forming of structure carbon in plant cell wall increasing crude fiber content. Energy was a metabolism product of energy resource foods such as carbohydrate including crude fiber, cellulose, hemicellulose and lignin digested by ruminal microbes in the digestive tract (Dewhurst et al. 2009). Energy produced from that metabolic process was used for maintenance; growth and production of milk, meat, egg, and wool (William 2010). Gross energy was one of crude fiber metabolic products in ruminant digestive tract with ruminal enzyme and microbes help. As reported by Dewhurst et al. (2009) that increase of gross energy of forage was always in line with increase of crude fiber of dry material of forage especially cellulose

Table 7. Energy content of *I. zollingeriana* in various canopy levels and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	3406.0	3875.0	4090.0	3790.3 ^b
Acid	4384.5	3623.0	3940.0	3982.5 ^a
Average	3895.3 ^b	3749.0 ^c	4015.0 ^a	

The different letters in column and row shows significant difference (P<0.05)

Table 8. Calcium (Ca) content of *I. zollingeriana* in various canopy levels and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	0.92	0.94	1.71	1.19 ^a
Acid	0.78	0.81	0.90	0.83 ^b
Average	0.85 ^b	0.88 ^b	1.31 ^a	

The different letters in column and row shows significant difference (P<0.05)

component which ease to be hydrolized by acid or cellulose enzyme resulted by ruminal microorganism into monomer glucose. Karim et al. (1991) reported that increase of plant age and dry stress decreased ratio of leaves/stems, meanwhile increased ratio of stems/leaves. This decreased crude protein content, but instead increased gross energy. The most gross energy in plant is in stem due to carbohydrate content in the form of crude fiber (cellulose, hemicellulose and lignin).

There was no interaction between oil palm canopy and soil acidity to calcium (Ca) content of *I. zollingeriana* (Table 8). Calcium (Ca) content under 7 years oil palm trees was significantly (P<0.05) higher by 1.31% than under the 2 and 5 years oil palm trees by 0.85 and 0.88%, respectively, however there was no significant difference between 2 and 5 years oil palm canopy treatment. Then, Ca content in neutral soil was significantly higher (P<0.05) by 1.19% than in acid soil by 0.83%. Blair et al. (1983) said that concentration of phosphor and calcium was significantly higher under dense canopy than under medium canopy and without canopy.

There was no interaction between oil palm canopy and super dolomit administration to phosphor of *I. zollingeriana* (Table 9). There was no significant difference between canopy level under 2, 5, and 7 years oil palm to phosphor content, as well as in soil acidity level. Blair et al. (1983) reported that phosphor (P) and calcium (Ca) concentration was significantly higher under dense canopy than under medium canopy and without canopy. Congdon & Addison (2003) said that N concentration in leaves was greatly influenced by

canopy, where its concentration increased under canopy than control, whereas it did not change significantly to concentration of phosphor in leaves.

Based on analysis of variance, there was no interaction between oil palm canopy and soil acidity to dry material digestibility of *I. zollingeriana* (Table 10). Digestibility of dry material under 2 years oil palm trees was significantly (P<0.05) higher by 71.53% than under 5 and 7 years oil palm trees by 65.45 and 62.78 %, respectively. It was significantly higher by 67.20% in neutral soil than in acid soil by 65.98%.

Digestibility of dry material decreased, because closer canopy would increase crude fiber in plant. Blair et al. (1983) reported that dry material digestibility was very good under full sunlight or medium canopy. Dry material digestibility by in vitro was the number of digestible and not excreted dry material in the form of faecess and was assumed as a part absorbed by animal (Chuzaeami & Bruchem 1990). One of the reasons of low dry material digestibility was high lygnin content in skin cell wall of plant which might prevent enzyme to normaly digest fiber. Sleugh et al. (2001) reported that decrease of dry material digestibility was in line with frequency of pruning due to accumulation of indigestible fiber, lignification increase and decrease of leaves/branches ratio, would form cell wall structure making it difficult to be digested by ruminal microbes. Digestibility value of grass and legume, generally decreased along with plants aged and decrease of soil water content due to increase of crude fiber concentration in plant tissue, increase of lignification and decrease of ratio leaves/stems (Nisa et al. 2004).

Table 9. Phospor content *I. zollingeriana* in various canopy levels and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	0.28	0.27	0.27	0.27 ^a
Acid	0.26	0.26	0.26	0.26 ^a
Average	0.27 ^a	0.27 ^a	0.27 ^a	

The different letters in column and row shows significant difference (P<0.05)

Table 10. Digestibility of dry material of *I. zollingeriana* in various canopy level and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	70.65	67.65	63.29	67.20 ^a
Acid	72.41	63.25	62.27	65.98 ^b
Average	71.53 ^a	65.45 ^a	62.78 ^c	

The different letters in column and row shows significant difference (P<0.05)

Table 11. Digestibility of organic material of *I. zollingeriana* in various canopy levels and soil acidity (%) of oil palm estate

Soil acidity	Canopy level (age of oil palm)			Average
	2 years	5 years	7 years	
Neutral	70.16	63.65	60.32	64.71 ^a
Acid	68.62	61.25	60.86	63.58 ^b
Average	69.39 ^a	62.45 ^b	60.59 ^c	

The different letters in column and row shows significant difference (P<0.05)

Based on analysis of variance, there was no interaction between oil palm canopy and soil acidity to organic material digestibility of *I. zollingeriana* (Table 11). Organic material digestibility under 2 years oil palm trees was significantly higher by 69.39% than those under 5 and 7 years oil palm trees by 62.45 and 60.59%, respectively. Then organic material digestibility in super dolomit administration treatment was significantly (P<0.05) higher by 64.71% than in soil without super dolomit by 63.58%.

Digestibility of organic material of forage was organic material value including crude protein, carbohydrate, fiber to digest and not excreted through faeces and might be used as indicator of overall forage quality. Low digestibility of organic material as well as dry material digestibility was caused by high crude fiber, especially lignin in its basic material of forage. The highest and lowest digestibility of organic material of *I. zollingeriana* by 76.02% and 63.86%, respectively was still higher than digestibility of *Gliricidia sepium* by 60.82% (Sánchez et al. 2005). González &

Hanselka (2002) said that digestibility of organic material of forage decreased significantly from rainy to dry season in line with increase of some crude fiber-forming components. (Hassen et al. 2007) stated that all of *Indigofera* species had higher ash, crude protein, and organic material digestibility with lower NDF concentration in spring.

CONCLUSION

Denser canopy level of oil palm (5 and 7 years old) significantly decreased fresh production of *I. zollingeriana* either in neutral and acid soil. Nutrient content of CP, CS, energy, Ca and P of *I. zollingeriana* increased along with level increase of oil palm canopy shade (5 and 7 years old), otherwise digestibility of dry and organic material were decrease. *I. zollingeriana* was not tolerant to dense oil palm canopy (5 and 7 years old), but had better quality and quantity in lesser canopy dense (2 years old).

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