INTERCROPPING OF *Orthosiphon stamineus* (Benth) WITH *Hevea brasiliensis* (Willd) AND *Durio zibethinus* (Murr) AMENDED WITH VARIOUS ORGANIC FERTILIZERS AND THEIR FINANCIAL ANALYSIS

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IJAZAH: **SARJANA SAINS (PERHUTANAN)**

SESI PENGAJIAN: 2007 - 2009

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Penulis: AFFENDY HASSAN TANDATANGAN PUSTAKAWAN

Alamat:

_____

Penyelia: Prof. Dr. Aminuddin Mohamad

Tarikh: 2009

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CERTIFICATION

NAME : **AFFENDY HASSAN**

MATRIC NO. : **PF2007-8015**

TITLE :**INTERCROPPING OF *Orthosiphon stamineus* (Benth) WITH *Hevea brasiliensis* (Willd) AND *Durio zibethinus* (Murr) AMENDED WITH VARIOUS ORGANIC FERTILIZERS AND THEIR FINANCIAL ANALYSIS**

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DECLARED BY

1. SUPERVISOR

PROF. DR. AMINUDDIN MOHAMAD _____

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

August 2009

Affendy Hassan
PF2007-8015

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ABSTRACT

Intercropping of *O. stamineus* (Benth) with *Hevea brasiliensis* (Willd) and *Durio zibethinus* (Murr) amended with various organic fertilizers and their financial analysis

Orthosiphon stamineus (Benth) or Misai kucing is a potential herb that can be intercropped under shade trees. The study was carried out at the nursery of School of International Tropical Forestry (SITF) Universiti Malaysia Sabah and fields of smallholders (rubber and durian) at Papar, Sabah. The objectives of this study were to determine the light intensity suitable to the growth of *O. stamineus* with different organic fertilizer applications, to evaluate the growth of *O. stamineus* rubber and durian canopies, to determine the soil properties and nutrient uptake of *O.stamineus* for the various fertilizer application regimes and to determine the financial feasibility of *O. stamineus* yields intercropped with rubber and durian. Amongst the relative light intensity (RLI) regime, 50% RLI was better than 30% and 100% RLI. The field planting distance used was 1.5 m X 0.45 m. Higher rate of fertilizer application gave higher yields of *O. stamineus.* Chicken dung was the best fertilizer followed by oil palm EFB and cow dung. The productivity using oil palm EFB and cow dung was smaller compared to chicken dung. Soil physical properties did not show any influence on the growth and yield of *O. stamineus*. However, the soil chemical properties influenced the growth based on the type of fertilizer applied. Project simulations showed that, intercropping of *O. stamineus* under rubber (0.9 kg fertilizer per plant) and under durian (0.9 and 0.6 kg per plant) using chicken dung is the most feasible financially. However, the other fertilizers are not feasible due to low yield and high cost of fertilizer per unit kilogram. The NPV under rubber was RM 47,413 (0.9 kg per plant only) and for durian was RM 91,751 (0.9kg per plant) and RM 60,414 (0.6kg per plant). The revenue and cost affect the NPV, IRR, B/C ratio and the payback period.

ABSTRAK

Orthosiphon stamineus (Benth) atau misai kucing adalah herba yang berpotensi untuk tanaman selingan di bawah teduhan pokok. Kajian telah dijalankan di tapak semaian Sekolah Perhutanan Tropika Antarabangsa (SPTA) dan tanaman di lapangan pekebun kecil (getah dan durian) di Papar, Sabah. Antara objektif kajian ini adalah untuk menentukan keamatan cahaya yang sesuai untuk pertumbuhan misai kucing dengan penggunaan baja organik yang berbeza, untuk menilai pertumbuhan misai kucing di bawah kanopi getah dan durian, untuk menentukan ciri-ciri tanah dan pengambilan nutrien misai kucing dengan berbagai jenis penggunaan baja serta untuk menentukan kebolehsandaran kewangan hasil tanaman selingan misai kucing dengan getah dan durian. Di antara keamatan cahaya relatif (RLI), 50% adalah terbaik berbanding 30% dan 100% RLI. Jarak tanaman yang digunakan adalah 1.5 m X 0.45 m. Kadar penggunaan baja yang tinggi juga mempengaruhi pengeluaran hasil yang tinggi untuk misai kucing. Tahi ayam adalah baja paling baik berbanding tandan sawit kosong (EFB) dan tahi lembu. Produktiviti oleh tandan sawit kosong (EFB) dan baja tahi lembu adalah lebih kecil berbanding tahi ayam. Ciri-ciri fizikal tanah tidak menunjukkan sebarang pengaruh terhadap pertumbuhan dan hasil misai kucing. Walaubagaimanapun, ciri-ciri kimia tanah mempengaruhi pertumbuhannya berdasarkan kepada jenis baja yang digunakan. Daripada pengiraan, tanaman selingan misai kucing di bawah getah (0.9 kg baja setiap pokok) dan di bawah durian (0.9 dan 0.6 kg setiap pokok) menggunakan tahi ayam adalah lebih bersandar. Walaubagaimanapun, baja yang lain adalah tidak menguntungkan disebabkan hasil yang rendah dan kos baja setiap unit kilogram adalah tinggi. Nilai Kini Bersih (NPV) di bawah getah adalah RM 47,413 (0.9kg setiap pokok) dan untuk duriian adalah RM 91,751 (0.9kg setiap pokok) dan RM 60,414 (0.6kg setiap pokok). Hasil dan kos mempengaruhi Nilai Kini Bersih (NPV), Kadar Pulangan Dalaman (IRR), Kadar Faedah Kos (B/C ratio) dan tempoh bayaran balik.

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LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
%	percentage
`	Minute
<	less than
cm	centimeter (s)
$cm\ cm^{-1}\ wk^{-1}$	centimeter per centimeter per week
$cmol_{+}/kg$	centimol charges per kilogram
DBH	diameter at breast height (1.3 m above ground level)
DMRT	Duncan Multiple Range Test
E	East
g	gram
kg	kilogram
ha	hectare
km	kilometer (s)
m	meter (s)
N	North
^{O}C	degree Celcius
pH	potential of hydrogen, followed by a number of 0 to 14 that describe how acid or alkaline a substance is
$mg\ kg^{-1}$	miligram per kilogram
S	South
t	ton

Appendix 1 Meteorological data

Station : Kota Kinabalu
Lat. : 05° 56' N
Long. : 116° 03' E
Ht. above M.S.L. : 2.3 m

Records of Monthly Rainfall Amount
Unit : mm

Month Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	234.9	76.8	29.6	260.4	114.9	324.8	315.6	215.4	197.8	291.3	335.8	390.6	2787.9
1997	71.1	192.7	4.9	165.2	285.2	95.8	216.0	110.4	95.2	396.3	271.6	16.2	1920.6
1998	10.1	0.3	Trace	13.7	29.7	174.7	356.6	622.5	201.8	318.6	264.3	260.9	2253.2
1999	374.8	154.2	163.6	151.4	288.9	127.4	95.9	261.2	282.8	466.8	291.2	250.6	2908.8
2000	52.1	231.0	207.3	279.7	112.6	355.3	46.4	315.0	229.5	561.0	303.9	279.6	2973.4
2001	215.3	47.1	408.6	151.4	115.2	361.4	110.3	172.3	392.6	638.5	281.2	262.0	3155.9
2002	83.0	6.6	1.6	146.0	105.2	171.6	81.4	374.4	315.8	236.2	360.6	84.8	1967.2
2003	75.0	8.8	84.3	45.6	128.0	169.8	395.0	215.2	291.6	532.2	181.8	201.8	2329.1
2004	39.0	24.4	93.8	63.2	366.8	100.1	166.2	91.4	274.2	429.4	167.2	81.7	1897.4
2005	59.4	7.6	109.2	45.6	350.7	634.6	630.8	366.2	183.4	447.0	596.9	571.6	4003.0
2006	299.2	117.2	127.4	243.8	421.1	658.6	272.8	193.0	394.2	416.2	57.6	148.6	3349.7
2007	190.0	27.8	200.0	103.8	146.8	194.8	313.0	267	259.9	430.3	282.9	231.7	2648.0
Month Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	19	12	9	19	12	20	10	21	15	25	23	16	201
1997	8	20	3	10	10	10	21	10	11	21	20	9	153
1998	2	1	0	4	9	18	24	25	18	19	24	20	164
1999	17	13	17	17	22	13	12	18	18	22	16	21	206
2000	15	23	20	20	14	22	8	23	19	25	22	20	231
2001	18	12	22	18	14	20	14	16	23	26	23	15	221
2002	12	3	3	11	12	17	8	20	20	19	19	10	154
2003	8	2	10	7	10	23	16	16	15	21	18	17	163
2004	11	6	10	8	18	10	19	11	24	17	21	16	171
2005	7	6	8	7	16	13	15	19	14	21	23	21	170
2006	18	11	12	15	17	21	11	20	22	19	14	16	196
2007	17	8	9	8	14	23	20	18	18	21	20	17	193

Records of 24 Hour Mean Temperature

Unit:℃

Month Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	26.0	26.3	27.3	27.8	28.0	27.5	27.9	27.3	27.7	27.0	26.8	26.5	27.2
1997	26.6	26.3	27.6	28.0	28.1	28.2	27.4	28.5	27.8	27.2	27.4	27.7	27.6
1998	27.5	27.9	29.1	29.2	30.0	28.3	27.3	27.6	27.9	27.6	27.2	27.1	28.1
1999	26.8	26.6	27.2	27.9	27.1	27.9	27.6	27.4	27.4	27.0	27.1	27.1	27.3
2000	26.8	26.4	27.1	27.3	28.2	27.2	28.2	27.2	27.6	27.2	27.1	27.2	27.3
2001	26.9	27.1	27.0	27.7	28.1	27.1	27.8	27.7	27.1	26.8	26.8	26.5	27.2
2002	26.3	26.6	27.6	28.2	28.3	27.6	28.2	27.5	27.2	27.2	27.1	27.6	27.5
2003	26.9	27.0	27.3	28.6	28.1	27.5	27.2	27.7	27.3	26.9	27.1	26.5	27.3
2004	26.8	26.7	27.5	28.5	27.6	27.7	26.9	27.8	26.7	26.9	26.9	26.9	27.2
2005	26.3	27.4	27.3	28.3	28.0	28.0	27.4	27.6	27.6	27.3	26.8	26.7	27.4
2006	26.9	27.0	27.2	27.3	27.5	27.0	28.1	27.5	26.9	26.9	27.6	27.4	27.3
2007	26.7	27.0	27.3	28.0	28.1	27.8	27.3	27.6	27.4	27.1	27.1	27.0	27.4

Records of Mean Maximum Temperature

Unit:℃

Month Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	29.9	29.8	31.4	32.3	32.5	32.1	32.4	31.8	31.9	31.5	30.9	31.5	31.5
1997	31.1	30.2	31.8	32.1	32.1	32.8	31.7	32.8	32.3	31.9	32.3	32.2	31.9
1998	31.9	32.4	33.8	33.5	34.0	33.0	31.9	32.0	32.3	31.7	31.4	30.9	32.4
1999	30.6	30.5	31.6	32.4	31.7	32.3	31.9	31.8	32.0	31.6	31.7	31.5	31.6
2000	31.1	31.0	31.6	31.9	32.8	31.6	32.8	31.8	32.3	31.4	31.6	31.3	31.8
2001	31.3	31.2	31.7	32.5	33.0	31.5	32.6	31.8	32.1	31.2	30.7	31.2	31.7
2002	31.0	31.2	32.7	33.6	33.6	32.5	32.7	32.0	31.8	32.0	32.2	32.9	32.4
2003	31.8	31.9	32.7	34.0	32.7	32.9	31.9	32.5	31.9	31.6	32.3	30.7	32.2
2004	31.5	31.7	32.7	34.0	32.3	32.1	31.9	32.3	32.1	31.6	32.5	31.6	32.2
2005	31.1	32.6	32.3	33.4	33.0	33.1	32.5	32.3	32.3	32.5	31.5	31.1	32.3

2006	31.6	31.7	31.8	32.7	32.6	31.9	32.7	32.4	31.7	31.7	32.9	32.7	32.2
2007	30.9	31.7	32.2	33.0	33.3	32.7	32.2	32.1	32.1	31.7	31.8	31.6	32.0

Records of Mean Minimum Temperature

Unit:℃

Month Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1996	23.2	23.1	23.5	23.8	23.9	23.9	24.3	24.1	24.2	24.2	23.6	23.3	23.7
1997	23.0	23.6	23.7	24.6	24.6	24.6	24.3	24.7	24.5	24.0	24.0	24.2	24.1
1998	23.5	24.0	24.6	25.5	26.5	25.1	24.5	24.5	24.5	24.4	24.4	24.1	24.6
1999	24.0	23.7	24.1	24.5	24.3	24.2	24.0	24.0	23.9	24.0	23.7	24.2	24.1
2000	23.5	23.6	23.8	24.2	24.3	24.1	24.4	23.9	24.1	24.3	23.9	24.1	24.0
2001	23.8	23.8	23.9	24.3	24.5	23.8	23.8	24.1	23.7	23.7	24.0	23.2	23.9
2002	23.0	23.3	23.9	24.5	24.7	24.2	24.4	23.7	23.7	23.8	23.9	23.9	23.9
2003	23.3	23.5	23.8	24.7	24.6	24.0	23.6	24.1	23.7	23.9	23.8	23.7	23.9
2004	23.7	23.3	24.0	24.8	24.3	24.0	23.6	24.1	23.5	23.7	23.5	23.9	23.9
2005	22.9	23.7	24.1	24.4	24.5	24.4	23.7	23.9	23.9	23.9	23.8	23.6	23.9
2006	23.7	23.8	23.9	23.8	24.1	23.8	24.4	23.9	23.7	23.7	23.9	24.1	23.9
2007	23.9	23.7	23.7	24.5	24.7	24.6	23.9	24.1	23.9	24.0	23.9	23.8	24.0

Appendix 2: Foliar Nutrient Content

Table 1: Foliar N (%) concentration of *O. stamineus* under Rubber

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	1.79a[b]	**2.44[a]**	**2.31[a]**	**2.10[a]**	1.59
dung	600	1.54a[b]	**2.03[a]**	**2.03[a]**	**1.56[a]**	1.64
Cow dung	900	**1.91[a]**	2.13a[b]	1.67[b]	1.34b	1.31
	600	**1.95[a]**	1.99a[b]	1.95[b]	1.14[b]	1.51
EFB Oil Palm	900	1.56a[b]	**2.41a**	2.04[b]	1.19[b]	1.67
Control	600	1.93a[b]	**2.18[a]**	1.79[b]	1.28[b]	1.44
	900	1.28[c]	1.95[b]	1.86[b]	**1.51[a]**	1.53
	600	1.05[c]	1.93[b]	1.89[b]	**2.23[a]**	1.64
	F Value	12.06	4.717	4.228	7.416	1.273
	P Value	<0.001	0.015	0.022	0.002	0.317

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 2: Foliar P (%) concentration of *O. stamineus* under Rubber

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.49	**0.93[a]**	**0.71[a]**	**0.99[a]**	**0.67[a]**
dung	600	0.52	**0.86[a]**	**0.69[a]**	**0.92[a]**	**0.69[a]**
Cow dung	900	0.50	0.62[c]	0.48[b]	0.49[c]	0.43[b]
	600	0.46	0.56[c]	0.44[b]	0.53[c]	0.47[b]
EFB Oil Palm	900	0.50	0.72[b]	0.45[b]	0.78[b]	0.44[b]
Control	600	0.51	0.69[b]	0.50[b]	0.72[b]	0.46[b]
	900	0.47	0.51[d]	0.43[c]	0.48[c]	0.42[b]
	600	0.51	0.47[d]	0.42[c]	0.47[c]	0.42[b]
	F Value	0.783	140.48	90.75	205.83	32.91
	P Value	0.520	<0.001	<0.001	<0.001	<0.001

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 3: Foliar K (%) concentration of *O. stamineus* under Rubber

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.30	**2.03[a]**	**1.01[a]**	**2.19[a]**	**1.40[a]**
dung	600	0.30	**1.81[a]**	**0.98[a]**	**1.87[a]**	**1.13[a]**
Cow dung	900	0.29	0.51[c]	0.45[c]	0.51[c]	0.47[c]
	600	0.30	0.50[c]	0.43[c]	0.49[c]	0.45[c]
EFB Oil Palm	900	0.28	1.20[b]	0.77[b]	1.35[b]	0.75[b]
Control	600	0.30	1.06[b]	0.70[b]	1.15[b]	0.67[b]
	900	0.29	0.32[d]	0.37[d]	0.33[d]	0.28[d]
	600	0.30	0.39[d]	0.33[d]	0.32[d]	0.29[d]
	F Value	0.290	283.79	1128.19	1837.33	195.03
	P Value	0.832	<0.001	<0.001	<0.001	<0.001

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 4: Foliar Mg (%) concentration of *O. stamineus* under Rubber

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.25	**0.36[a]**	**0.34[a]**	**0.37[a]**	**0.34[a]**
dung	600	0.25	**0.35[a]**	**0.33[a]**	**0.35[a]**	**0.33[a]**
Cow dung	900	0.25	0.30[b]	0.30[b]	0.31[b]	0.30[b]
	600	0.25	0.29[b]	0.29[b]	0.30[b]	0.28[b]
EFB Oil Palm	900	0.25	**0.35[a]**	**0.33[a]**	**0.35[a]**	**0.34[a]**
Control	600	0.25	**0.35[a]**	**0.34[a]**	**0.37[a]**	**0.33[a]**
	900	0.26	0.27[c]	0.28[c]	0.28[c]	0.26[c]
	600	0.25	0.28[c]	0.29[c]	0.28[c]	0.26[c]
	F Value	0.515	434.65	318.91	273.89	306.39
	P Value	0.678	<0.001	<0.001	<0.001	<0.001

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 5: Foliar Ca (%) concentration of *O. stamineus* under Rubber

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.17	**0.40[a]**	**0.37[a]**	**0.42[a]**	**0.38[a]**
dung	600	0.14	**0.36[a]**	**0.33[a]**	**0.39[a]**	**0.34[a]**
Cow dung	900	0.15	0.31[c]	0.28[d]	0.33[c]	0.28[c]
	600	0.17	0.29[c]	0.26[d]	0.29[c]	0.27[c]
EFB Oil Palm	900	0.16	0.35[b]	0.33[b]	0.35[b]	0.33[b]
Control	600	0.15	0.36[b]	0.31[b]	0.35[b]	0.31[b]
	900	0.16	0.26[d]	0.29[c]	0.25[d]	0.24[d]
	600	0.16	0.26[d]	0.29[c]	0.25[d]	0.24[d]
	F Value	0.031	648.72	70.67	325.83	247.89
	P Value	0.992	<0.001	<0.001	<0.001	<0.001

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 6: Foliar N (%) concentrations of *O. stamineus* under Durian

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	**2.50[a]**	**3.36[a]**	**2.97[a]**	**2.42[a]**	**2.21[a]**
dung	600	**2.41[a]**	**2.89[a]**	**2.77[a]**	**2.83[a]**	**2.12[a]**
Cow dung	900	2.19a[b]	2.43[b]	2.27[b]	2.34[b]	1.88[b]
	600	2.36a[b]	2.57[b]	2.45[b]	2.06[b]	1.71[b]
EFB Oil Palm	900	2.51a[b]	2.52[b]	2.44[b]	1.90[ab]	1.82[b]
Control	600	2.24a[b]	2.67[b]	2.40[b]	2.10[ab]	1.66[b]
	900	2.09[c]	2.15[c]	2.10[c]	2.16[b]	1.89[b]
	600	2.10[c]	2.07[c]	1.89[c]	1.82[b]	1.15[b]
	F Value	2.562	16.94	18.04	2.781	6.713
	P Value	0.091	<0.0001	<0.0001	0.075	0.004

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 7: Foliar P (%) concentrations of *O. stamineus* under Durian

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.47	**0.99^{a}**	**0.69^{a}**	**1.04^{a}**	**0.72^{a}**
dung	600	0.49	**0.96^{a}**	**0.68^{a}**	**0.95^{a}**	**0.69^{a}**
Cow dung	900	0.50	0.61^{c}	0.44^{c}	0.51^{c}	0.46^{c}
	600	0.47	0.48^{c}	0.40^{c}	0.45^{c}	0.45^{c}
EFB Oil Palm	900	0.46	0.81^{b}	0.51^{b}	0.74^{b}	0.57^{b}
Control	600	0.48	0.73^{b}	0.48^{b}	0.74^{b}	0.53^{b}
	900	0.48	0.46^{d}	0.49^{b}	0.50^{c}	0.45^{c}
	600	0.46	0.46^{d}	0.49^{b}	0.49^{c}	0.46^{c}
	F Value	0.269	129.92	175.25	184.56	53.32
	P Value	0.847	<0.0001	<0.0001	<0.0001	<0.0001

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 8: Foliar K (%) concentrations of *O. stamineus* under Durian

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.30^{b}	**2.25^{a}**	**1.79^{a}**	**2.26^{a}**	**1.90^{a}**
dung	600	0.29^{b}	**1.95^{a}**	**1.64^{a}**	**1.93^{a}**	**1.62^{a}**
Cow dung	900	0.28^{ab}	0.41^{c}	0.37^{c}	0.42^{c}	0.37^{c}
	600	0.32^{ab}	0.42^{c}	0.37^{c}	0.41^{c}	0.37^{c}
EFB Oil Palm	900	0.30^{ab}	1.31^{b}	0.75^{b}	1.35^{b}	0.74^{b}
Control	600	0.31^{ab}	1.16^{b}	0.68^{b}	1.27^{b}	0.74^{b}
	900	**0.32^{a}**	0.38^{d}	0.32^{d}	0.32^{d}	0.29^{d}
	600	**0.32^{a}**	0.37^{d}	0.32^{d}	0.31^{d}	0.30^{d}
	F Value	2.549	11677.83	4334.09	4855.73	2671.92
	P Value	0.092	<0.0001	<0.0001	<0.0001	<0.0001

Note: Means with same letter were not significantly different at p<0.05 (by columns)

Table 9: Foliar Mg (%) concentrations of *O. stamineus* under Durian

Treatment	Rate (g)	Month				
		0	**3**	**6**	**9**	**12**
Chicken	900	0.25	**0.36^{a}**	**0.34^{a}**	**0.37^{a}**	**0.34^{a}**
dung	600	0.25	**0.35^{a}**	**0.34^{a}**	**0.37^{a}**	**0.34^{a}**
Cow dung	900	0.25	0.30^{b}	0.30^{b}	0.30^{b}	0.30^{b}
	600	0.25	0.29^{b}	0.29^{b}	0.30^{b}	0.29^{b}
EFB Oil Palm	900	0.25	**0.36^{a}**	**0.34^{a}**	**0.37^{a}**	**0.34^{a}**
Control	600	0.24	**0.35^{a}**	**0.33^{a}**	**0.37^{a}**	**0.34^{a}**
	900	0.25	0.26^{c}	0.27^{c}	0.29^{c}	0.27^{c}
	600	0.25	0.26^{c}	0.27^{c}	0.27^{c}	0.26^{c}
	F Value	0.633	371.35	298.93	331.31	281.42
	P Value	0.604	<0.0001	<0.0001	<0.0001	<0.0001

Note: Means with same letter were not significantly different at p<0.05 (by columns)