ORIGINAL ARTICLE

Nitrogen mineralization in soil amended with mesocarp fiber of oil palm and other wastes : A greenhouse study

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Abstract

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Mesocarp fiber of oil palm, sludge cake from frozen seafood factory, rick husk and organic fertilizer were mixed with a soil and incubated for 0, 15, 30, 45, 60, 75 and 90 days in plastic pots. At the end of each incubation period, NH^+_4-N and NO^-_3-N contents were determined by MgO-Devada alloy steam distillation method. N-mineralization differed depending upon incubation period and types of organic amendment. At 60 days of incubation, N-mineralization of the amended soil had increased slightly. NO^-_3-N content was higher than NH^+_4-N content at all incubation periods especially in the soil amended with of the mesocarp fiber of oil palm. The soil inoculated with *Sclerotium rolfsii* had higher rates of N-mineralization than the soil without *S. rolfsii* with the exception of the soil amended with mesocarp fiber of oil palm at 5 g/kg. soil and rick husk during 60-90 days of incubation period. NO^-_3-N, was the dominant product of N-mineralization in soil both added with *S. rolfsii* and without *S. rolfsii* .

Key words : agricultural waste, mesocarp fiber of oil palm, N-mineralization, *Sclerotium rolfsii*

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การปลดปล่อยไนโตรเจนที่เป็นประโยชน์ได้ของดินผสมเส้นใยกากปาล์มและวัสดุเหลือใช้อื่น ๆ ในสภาพเรือนทดลอง

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เส้นใยของกากปาล์ม กากตะกอนจากโรงงานอาหารทะเลแช่แข็ง แกลบ และปุ๋ยอินทรีย์จะผสมกับดินในกระถางพลาสติก และบ่มไว้เป็นเวลา 0 15 20 45 60 75 และ 90 วัน เมื่อการบ่มแต่ละช่วงสิ้นสุด จึงทำการวิเคราะห์หาปริมาณ NH_4^+-N และ NO_3^--N โดยวิธี MgO-Devada alloy steam distillation ซึ่งพบว่าปริมาณไนโตรเจนที่ถูกปลดปล่อยแตกต่างกันในแต่ละช่วงเวลาของการบ่มและชนิดของวัสดุอินทรีย์ที่ผสมในดิน ในช่วง 60 วันแรกของการบ่ม ปริมาณ N ที่ถูกปลดปล่อยจะค่อย ๆ เพิ่มขึ้น และทุกช่วงเวลาของการบ่มปริมาณ NO_3^--N สูงกว่าปริมาณ NH_4^+-N โดยเฉพาะดินที่ผสมเส้นใยกากปาล์ม การใส่เชื้อ *Sclerotium rolfsii* ทำให้ปริมาณไนโตรเจนที่ถูกปลดปล่อยจากดินช่วงเวลา 60-90 วัน สูงกว่าดินที่ไม่ใส่เชื้อ *S. rolfsii* ยกเว้นในดินผสมเส้นใยกากปาล์มอัตรา 5 กรัม/ดิน 1 กก. ไนโตรเจนที่ถูกปลดปล่อยส่วนใหญ่อยู่ในรูป NO_3^- ทั้งในดินที่ใส่เชื้อและไม่ใส่เชื้อ *S. rolfsii*

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Agricultural and industrial wastes have been utilized in various aspects to improve crop productivity. An attempt to utilize these wastes occurs as a result of environmental problems associated with agricultural and industrial activities (Pierzyski *et al.*, 1994). In general, wastes utilization has been viewed as a means to improve soil fertility. Furthermore, addition of organic wastes also has other benefit such as the suppression of soilborne diseases (Keinath, 1996; Osunlaja, 1990). For instance, Singh *et al.* (1981) found that amending soil with organic substrates was effective in suppressing root rot disease of *Cicer arietnum* caused by *Rhizoctonia bataticola*. Agricultural waste such as ground mesocarp fiber of oil palm had a potential to be used in controlling damping-off of Chinese kale (*Brassica alboglabra*) caused by *Sclerotium rolfsii* (Kanjanamaneesathian *et al.*, 1999). However, soil amendment by adding organic substrates into soil, especially those which had high C/N ratio, may have an effect on nitrogen immobilization which may have affect soil fertility. Chescheir *et al.* (1986) suggested that types of organic materials and their chemical compositions may cause variation in nitrogen mineralization. With this dilemma, it is necessary to study the nitrogen-release pattern of organic substrates in a soil environment in order to utilize these substrates without causing a deleterious effect on soil fertility and/or plant disease problem.

In the South of Thailand, there are various wastes associated with agricultural and industrial activities. For instance, a factory which extracts cooking oil from oil palm fruits produces a vast quantity of organic materials such as mesocarp fiber. This organic material is abundant and the source has not been fully utilized. Sludge cake from frozen seafood factory is also another source of organic waste which has potential for improving soil fertility because it has quite low C/N ratio. To gain more data on the possibility of using these wastes effectively, we have investigated nitrogen mineralization in soil amended with ground mesocarp fiber of oil palm and other agricultural and industrial wastes.

The objectives of this study are: (1) to investigate the nitrogen mineralization pattern in soil amended with different types of organic

wastes i.e. mesocarp fiber of oil palm, sludge cake from frozen seafood factory, rice husk and organic fertilizer, (2) to compare nitrogen mineralization in the amended soil in the presence and absence of *S. rolfsii.*

Materials and Methods

Agricultural and industrial wastes preparation and analysis

Agricultural and industrial wastes used in this experiment are listed in Table 1.

These wastes were ground and sieved though a 2 mm. seive and analyzed at the Central Laboratory Center, the Faculty of Natural Resources, (FNR), Prince of Songkla University (PSU). Some of their chemical characteristics as shown in Table 1. The ground mesocarp fiber of oil palm after oil extraction will be referred to as oil palm throughout the text.

Soil analysis and *Sclerotium rolfsii* preparation

Soil was collected from a vegetable growing area at Bang Klam District, Songkhla Province. This soil sample was air-dried and seived through 2 mm. Some chemical and physical properties of the soil were analyzed. This soil had a sandy loam texture (66% sand, 18.6 % silt and 14.8 % clay), with pH 6.8, 2.3% organic matter, total N 0.1%, available P 1,089 mg/kg soil, exchangeable K 0.5 cmol(+)/kg, exchangeable Ca 8.4 cmol(+)/kg and exchangeable Mg 0.8 cmol(+)/kg .

S. rolfsii was originally isolated from pumpkin fruit from the field of the Department of Pest Management, FNR, PSU. Inoculum of *S. rolfsii* was prepared by transferring mycelia of *S. rolfsii* onto sterile sorghum seeds (1 kg) in a plastic bag. This bag was incubated at room temperature (26-32 ^{o}C) until mycelia of *S. rolfsii* completely colonised the sorghum seeds. These sterile the sorghum seeds (7.5 g) colonised with *S. rolfsii* were later mixed with soil and used in the experiment.

Treatments and experimental design

Experiment 1

In the first experiment, two rates of oil palm and sludge cake were used ; 5 g and 10 g for oil palm and 2.5 g and 5 g for sludge cake. The other wastes were used at 5 g and unamended soil was a control treatment. One kilogram of soil was throughly mixed with each waste and sterilized water was added to maintain a moisture equivalent at 60% of water holding capacity. This mixture was placed in a plastic pot (15 cm diameter)

Table 1. Nutrient status of some agricultural and industrial wastes.

Type of wastes	C/N Ratio	Moisture (%)	Total N (%)	Organic carbon (%)	pH (1:5H_2O)	EC (mS-cm^{-1}) (1:5H_2O)
Oil palm [(A)]	53.1	7.6	0.96	51.27	5.2	1.9
Organic 1 [(B)]	12.7	36.7	0.89	11.33	7.9	2.2
Organic 2 [(C)]	23.8	44.3	0.37	8.80	8.8	3.3
Rice husk [(D)]	77.0	49.5	0.30	23.08	4.7	6.0
Sludge cake [(E)]	5.0	8.6	8.86	44.18	5.8	6.6

(A) Oil palm which had been processed, extracted for oil in palm oil processing factory and the air dried mesocarp fiber was ground.
(B) Organic fertilizer product from garbage processing factory and had been commercialised at a garden shop in Hat Yai.
(C) Organic fertilizer from a whiskey brewing factory.
(D) Rice husk mixed with fermented molasses.
(E) Sludge cake from frozen seafood factory. The solid portion was compressed and dried at 65 -70 ^{o}c.

lined with a plastic bag and incubated for 0, 15, 30, 45, 60, 75 and 90 days in a glasshouse of the Faculty of Natural Resources, PSU. Each treatment consisted of 4 replications.

Experiment 2

The second experiment was similar to the first experiment except that 7.5 g of *S. rolfsii* colonized sorghum seeds was added to each replication 15 days after amending soil with the oil palm and the other agricultural wastes.

At the end of each incubation period, 10 g of the soil mixture was sampled from each replication and extracted with 100 ml of 2 M KCl ; the extractants from individual treatments and replications were analysed for the amount of NH^+_4 and NO^-_3 as described by Keeney and Nelson (1982)

Data analysis

Data were analyzed using the SPSS (+PC) computer package. One way ANOVA was carried out on N-mineralization, NH^+_4 - N and NO^-_3 - N. Means were then compared with Least Significant Difference (LSD).

Results and Discussion

N-mineralization in soil without *S. rolfsii*

The amounts of N-mineralization of the soil amended with oil palm and the other agricultural wastes were higher than in the control (Figure 1) During 60 days of incubation, N-mineralization of amended soil had increased slightly. Sludge cake which had lowest C/N ratio had highest N-mineralization, while the soil amended with oil palm had N-mineralization lower than rice husk, the substrate which had highest C/N ratio. This result may suggest that apart from C/N ratio, other parameters may also play an important role in the N-mineralization process. These parameters include the chemical composition of wastes (Chescheir *et al.*, 1986), lignin and polyphenol content (Fox *et al.*, 1990), crude protein content (Hattori and Mukai, 1986; Oglesby and Fownes, 1992) and microbial biomass (Bloem *et al.*, 1997). Soil amended with oil palm and other agricultural wastes except organic 2 had significantly increased ammonium form of nitrogen at 60 days after incubation compared with control (Table 2). However, NH^+_4-N content was lower than NO^-_3-N content at all incubation periods (Table 3). This result indicated that under aerobic incubation of nitrogenous materials NO^-_3-N content was higher than NH^+_4-N content (N' Dayegamiye *et al.*, 1997). Apart from nitrification, NO^-_3-N may occur from the oxidation of other nitrogen compound in soil such as protein and ribonucleic acid (Bloem *et al.*, 1997). NO^-_3-N content of amending soil greatly increased between 75-90 days, particularly in soil amended with oil palm at 5 g/kg soil (Table 3).

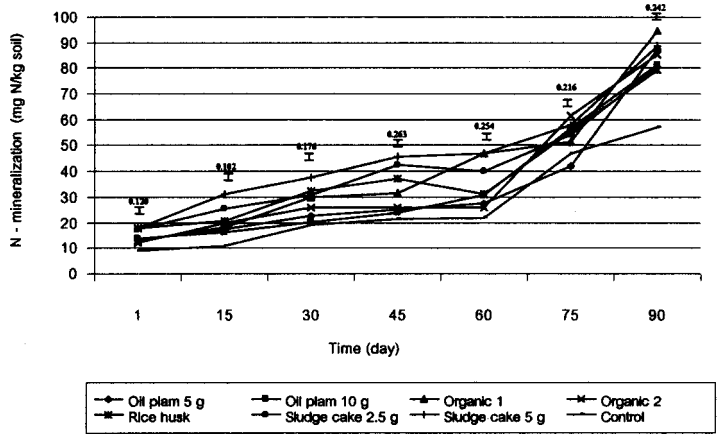

Figure 1. Effect of organic amendment on N-mineralization in soil without *S.rolfsii* during 90 days of incubation in the greenhouse.

Table 2. Effect of organic amendments on NH_4^+ - N (mg/kg as N) in soil without *S. rolfsii* during 90 days of incubation in a greenhouse.

Treatment	Incubation time (days)							LSD at P < 0.05
	1	15	30	45	60	75	90	
Oil palm 5 g	3.89	4.34	5.66	6.74	7.61	12.56	19.04	0.096
Oil palm 10 g	3.36	3.82	3.85	5.21	8.16	14.44	19.63	0.108
Organic 1	4.07	4.49	4.09	5.75	8.16	9.56	20.14	0.025
Organic 2	3.71	3.95	4.06	4.26	6.10	14.42	21.97	0.125
Rice husk	5.37	6.33	7.04	7.61	9.13	10.16	13.79	0.082
Sludge cake 2.5 g	4.13	4.26	5.07	7.22	15.52	16.00	19.77	0.128
Sludge cake 5 g	6.28	6.87	8.22	12.81	12.56	15.82	20.13	0.105
Control	2.86	4.01	5.35	6.41	6.58	8.86	14.24	0.106
LSD at P < 0.05	**0.035**	**0.021**	**0.024**	**0.089**	**0.075**	**0.197**	**0.134**	

Table 3. Effect of organic amendments on NO_3^- - N (mg/kg as N) in soil without *S. rolfsii* during 90 days of incubation in a greenhouse.

Treatment	Incubation time (days)							LSD at P < 0.05
	1	15	30	45	60	75	90	
Oil palm 5 g	9.67	13.18	16.88	18.21	19.92	29.55	68.51	0.130
Oil palm 10 g	10.29	12.27	16.23	18.53	22.78	42.11	61.76	0.186
Organic 1	9.08	15.27	33.97	25.85	38.74	42.05	74.72	1.155
Organic 2	8.26	15.79	21.78	21.78	19.71	47.03	63.44	0.065
Rice husk	12.52	14.42	25.16	27.10	22.13	45.21	65.43	0.312
Sludge cake 2.5 g	13.31	21.44	25.69	35.42	24.51	38.30	60.76	1.198
Sludge cake 5 g	11.36	24.36	29.56	33.08	34.91	49.23	68.44	0.108
LSD at P < 0.05	0.112	0.183	0.176	0.263	0.236	0.125	0.155	

N- mineralization in soil with *S. rolfsii*

After amending soil with oil palm and other agricultural wastes, N-mineralization had increased significantly, particularly between 15 to 45 days, in soil with the pathogen present (Figure 2). At 60 days of incubation, N-mineralization of amended soil decreased significantly except amending soil with organic 1. The strong reduction of N-mineralization was probably due to *S. rolfsii* growth (Bloem *et al.*, 1997). N-mineralization of soil amended with organic 1 slightly increased during the incubation period. This results indicated that organic 1 had high degree of maturity and N-mineralization rate was maintained at constant value (Castellanos and Pratt, 1981; Aoyama and Nozawa, 1993; Mckenney *et al.*, 1995). During 45-90 days, immobilization of nitrogen occurred in soil mixture amended with oil palm and rice

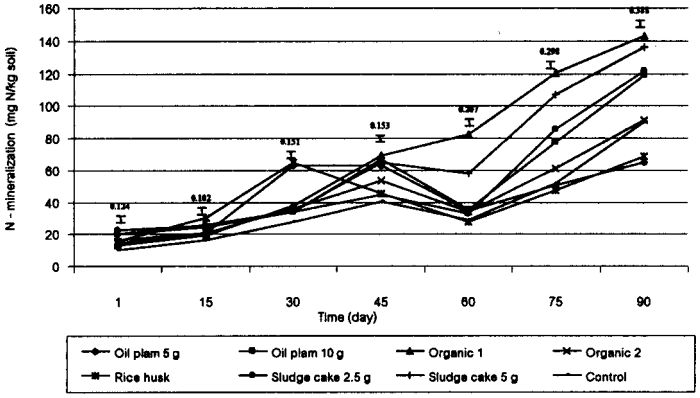

Figure 2. Effect of organic amendment on N-mineralization in soil with *S.rolfsii* during 90 days of incubation in the greenhouse.

Table 4. Effect of organic amendments on NH^+_4 - N(mg/kg as N) in soil with *S.rolfsii* during 90 days of incubation in a greenhouse.

Treatment	Incubation time (days)							LSD at P < 0.05
	1	15	30	45	60	75	90	
Oil palm 5 g	6.10	18.85	43.39	36.40	4.64	10.84	17.37	0.088
Oil palm 10 g	8.45	10.49	18.29	45.68	5.96	7.15	9.41	0.118
Organic 1	2.76	7.31	13.48	27.34	10.10	19.51	23.60	0.034
Organic 2	5.07	9.11	19.40	28.98	11.14	12.58	20.45	0.128
Rice husk	6.18	11.73	35.57	18.27	2.97	9.29	14.24	0.140
Sludge cake 2.5 g	9.52	13.96	18.98	25.93	7.16	18.83	22.00	0.071
Sludge cake 5 g	7.27	9.84	14.89	34.49	10.62	21.14	30.52	0.095
Control	2.56	6.83	10.89	19.10	5.07	9.93	16.29	0.105
LSD at P < 0.05	**0.080**	**0.058**	**0.122**	**0.156**	**0.091**	**0.086**	**0.093**	

husk, the substrates which had C/N ratio at 53.1 and 77.0 respectively.

NH^+_4 -N content was very low when compared with the mineralized N ($NH^+_4 + NO^-_3$ - N) in each incubation period (Table 4). However during 15-45 days, NH^+_4 -N content in soil amended with *S. rolfsii* was higher than in soil without *S. rolfsii.* At 60 days, NH^+_4 -N content in inoculated soil amended with oil palm and other agricultural wastes was reduced significantly. The strong reduction of NH^+_4 -N was possibly due to the utilization of nitrogen by microbes from inorganic rather than from organic source. However, at the end of incubation period, NH^+_4 -N content of amended soil was significantly higher than control treatment except for soil amended with rice husk, Although NH^+_4 -N content had reduced in some incubation period, NO^-_3 - N content greatly increased in all incubation periods and this content was higher than in soil without *S. rolfsii* (Table 5).

Table 5. Effect of organic amendments on NO_3^- - N (mg/kg as N) in soil with *S. rolfsii* during 90 days of incubation in a greenhouse.

Treatment	Incubation time (days)							LSD at P < 0.05
	1	15	30	45	60	75	90	
Oil palm 5 g	10.36	12.13	19.16	26.69	29.73	39.86	47.38	0.103
Oil palm 10 g	11.52	13.87	15.64	21.30	29.18	70.45	109.65	0.167
Organic 1	10.61	12.04	24.31	41.75	72.17	100.65	119.70	0.181
Organic 2	9.39	11.73	16.31	24.48	22.73	48.55	71.10	0.100
Rice husk	9.51	18.46	29.05	27.15	24.54	38.23	54.45	0.089
Sludge cake 2.5 g	13.32	11.30	15.34	18.73	25.70	67.05	99.85	0.118
Sludge cake 5 g	12.62	16.15	19.49	30.15	47.05	86.17	105.33	0.434
Control	7.16	9.82	16.63	20.95	23.69	41.92	73.17	0.134
LSD at P < 0.05	0.094	0.080	0.092	0.074	0.165	0.259	0.383	

Conclusion

N-mineralization differed depending upon incubation period and type of organic amendments. During 60-90 days, the soil inoculated with *S. rolfsii* had higher N-mineralization than that of the soil without *S. rolfsii*, except the soil amended with oil palm at 5 g/kg soil and with rice husk. Thus, amending the soil with some agricultural wastes such as organic fertilizer and sludge cake may aggravate plant disease problem because the pathogen has the capacity to ultilize N-content in these substrates. On the other hand, oil palm has a potential to be ultilized for soil fertility improvement with least effect on the possibility of increasing plant disease problem. This finding supported the results obtained from Kanjanamaneesathian *et al*., (1999) who demonstrated that oil palm 5 g/kg soil reduced percent post emergent damping-off of Chinese kale seedling caused by *S. rolfsii.* NO_3^--N was the dominant product of N-mineralization in soil both with added *S. rolfsii* and without *S. rolfsii.*

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References

Aoyama, M. and Nozawa, T. 1993. Microbial biomass nitrogen and mineralization-immobilization process of nitrogen in soil incubated with various organic materials. Soil Sci. Plant Nutr. 39 : 23-32.

Bloem, J.D. Ruiter, P. and Bouwman, L. 1997. Soil food webs and nutrient cycling in agroecosystems. **In** D.J. Elsas van, T.J. Trevors and H.M.E. Wellington (eds). pp : 245-275. Modern Soil Microbiology. Marcel Dekker, Inc. New York.

Castellanos, J. and Pratt, P.F. 1981. Mineralization of manure nitrogen : Correlation with laboratory indexes. Soil Sci. Soc. Am J. 45 : 345-357.

Chescheir, G.M., Westerman, P.W. and Safleg, Jr. L.M. 1986. Laboratory method for estimating available nitrogen in manure and sludges. Agric. Wastes. 18: 175-195.

Fox, R.H., Myers, R.J.T. and Vallis, I. 1990. The nitrogen mineralization rate of legume residues in

soil as influenced by their polyphenol, lignin, and nitrogen contents. Plant and Soil 129 : 251-259.

Hattori, H. and Mukai, S. 1986. Decomposition of sewage sludges in soil as affected by their organic matter composition. Soil Sci. Plant Nutr. 32 : 421-432.

Kanjanamaneesathian, M., Leowarin, W., Pengnoo, A. and Nooduang, A. 1999. Evaluation of agricultural and industrial wastes for the control of damping-off of Chinese Kale (*Brassica alboglabra Bailey*) caused by *Sclerotium rolfsii* Sacc. Thai J. Agric.Sci. 32 (4) : 547-555.

Keeney, D.R. and Nelson, D.W. 1982. Nitrogen-inorganic form. **In** A.L. Page, R.H. Miller, D.R. Keeney (eds.) Methods of Soil Analysis, Part 2, 2nd ed., pp. 643-693. Agronomy Monog. 9. ASA and SSSA. Medison, Wisconsin.

Keinath, A.P. 1996. Soil amendment with cabbage residue and crop rotation to reduce gummy stem blight and increase growth and yield of watermelon. Plant Disease 80(5) : 564-570.

Mckenney, D.J., Wang, S.W., Drury, C.F. and Findlay, W.I. 1995. Denitrification, immobilization, and mineralization in nitrate limited and nonlimited residue-amended soil. Soil Sci. Soc. 59 : 118-124.

N'Dayegamiye, A., Royer, R. and Audesse, P. 1997. Nitrogen mineralization and availability in manure compost from Que'bec biological farms. Can. J. Soil Sci. 77 : 345-350.

Oglesby, A.K. and Fownes, H.J. 1992. Effects of chemical composition on nitrogen mineralization from green manure of seven tropical leguminous trees. Plant and Soil 143 : 127-129.

Osunlaja, S.O. 1990. Effect of organic soil amendment on the incidence of stalk rot of maize. Plant and soil 127 : 237-241.

Pierzyski, M.G., Sims, J.T. and Vance, G.F. 1994. Soil and Environmental Quality. CRC Press, Inc. Florida.

Singh, P.J., Nagra, P. and Mehrotra, R.S. 1981. Effect of organic amendments on root rot of gram (*Cicer arietinum* L.) and their influence on plant growth. Plant and Soil 63 : 199-207.