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Full Length Research Paper

Effect of humin-urea-rock phosphate amendment on Bekenu series (Tipik Tualemkuts) soil

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Application of crude humin with urea and Egyptian rock phosphate (ERP) may reduce ammonia loss from urea. This study was conducted to determine the effect of mixing crude humin with urea and ERP on ammonia volatilization and selected soil chemical properties. Crude humin from four different composts was mixed with urea and ERP and ammonia loss from these treatments were evaluated using the closed-dynamic air flow system. Standard procedures were used to determine ammonia loss, soil pH, total nitrogen, exchangeable ammonium, available nitrate, exchangeable phosphorus, cations, organic matter, total organic carbon and cation exchange capacity. Amending urea with crude humin had no effect on total amount of ammonia loss. However, addition of the crude humin significantly increased pH, organic matter, total organic carbon, cation exchange capacity (CEC) and exchangeable cations of Bekenu series (Tipik Tualemkuts). Crude humin from selected waste compost can be used to improve soil chemical properties.

Key words: Crude humin, urea, rock phosphate, ammonia loss, soil chemical properties.

INTRODUCTION

Soil amendment is important in sustaining soil quality. Bekenu series (Tipik Tualemkuts) is acidic soil that is generally less fertile (Paramananthan, 2000) due to low pH, cation exchange capacity (CEC), exchangeable cations and organic matter content. Humin with higher organic matter, mineral content and CEC may improve the soil quality. A study by Petrus et al. (2010) showed that addition of crude humin from composted sago waste increases soil pH, exchangeable magnesium, CEC, total carbon and organic matter. In the same study, addition of the humin enhanced plant growth, increased dry matter production, and nutrient use efficiency in maize plant.

However, the effect of amending urea with humin on ammonia loss and phosphorus use efficiency is unknown. Application of urea by surface broadcast which is the normal practice in agriculture leads to nitrogen loss through urea hydrolysis and ammonia volatilization. This nitrogen loss ranges from 28 to 50% (Ahmed et al., 2006a, b, c; Bernard et al., 2009, 2011; Reeza et al., 2009; Yusuff et al., 2009; Shamsuddin et al., 2009) and it is considered a waste of money. Ammonia volatilization is influenced by soil microsite and environmental factors. Ammonia loss from urea can be reduced with higher CEC (Sommer et al., 2006; Omar et al., 2010; Latifah et al., 2011a, b, c) and lower soil microsite pH (Stevens et al., 1992; Omar et al., 2010; Latifah et al., 2011a, b, c), moisture, temperature (Sommer et al., 1991), organic matter content and urease activity (Watson et al., 1994). Higher CEC of humin may effectively retain ammonium ions from volatilizing from urea. This study was conducted to determine the effect of mixing crude humin with urea and Egyptian rock phosphate (ERP) on ammonia volatilization and selected soil chemical properties.

MATERIALS AND METHODS

Bekenu series (Tipik Tualemkuts) soil was sampled at 0 to 25 cm in

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Table 1. Selected chemical and physical properties of Bekenu series soil.

Property	Data obtained (0-25 cm)	Paramananthan (2000) (0-36 cm)
pH_{water}	4.41	4.6-4.9
pH_{KCl}	3.25	3.8-4.0
CEC (cmol kg^{-1})	11.97	3.86-8.46
Total N (%)	0.08	0.04-0.17
Exchangeable NH_4^+ (mg kg^{-1})	21.02	nd
Available NO_3^- (mg kg^{-1})	7.01	nd
Available P (mg kg^{-1})	4.85	nd
Exchangeable K(cmol kg^{-1})	0.10	0.05-0.19
Exchangeable Ca (cmol kg^{-1})	0.25	0.01
Exchangeable Mg (cmol kg^{-1})	0.34	0.07-0.21
Exchangeable Na (cmol kg^{-1})	0.22	0.01
Exchangeable Fe (cmol kg^{-1})	0.09	nd
Exchangeable Cu (cmol kg^{-1})	Trace	nd
Exchangeable Zn (cmol kg^{-1})	0.01	nd
Exchangeable Mn (cmol kg^{-1})	0.02	nd
C/N Ratio	28.93	14-15
Ash content (%)	95.81	nd
Total organic matter (%)	4.19	nd
Total organic carbon (%)	2.43	0.57-2.51
Bulk density (g cm^{-3})	1.16	nd
Sand %	71.04	72-76
Silt %	14.58	8-9
Clay %	14.38	16-19
Texture	SCL	SCL

CEC: Cation exchange capacity; nd: not determined; SCL: sandy clay loam.

an undisturbed area of Universiti Putra Malaysia, Bintulu Sarawak Campus, Malaysia, using an auger. The soil was air-dried, crushed and passed through a 2 mm sieve. The soil was analyzed prior and at the end of incubation for texture using hydrometer method (Tan, 2005); pH in distilled water and 1 M KCl (at ratio of 1:2.5 soil:water or KCl) using a glass electrode (Peech, 1965); ash, organic matter and total organic carbon using loss-on-ignition method (Piccolo, 1996); total nitrogen using Kjedahl method (Bremner, 1965); available NO_3 and exchangeable NH_4 (Keeney and Nelson, 1982); available cations and phosphorus extracted using double acid method (Mehlich, 1953), cations were determined using atomic absorption spectrometer (PerkinElmer AAnalyst 800), available P using the blue method (Murphy and Riley, 1962); and CEC was determined by the leaching method (Cottenie, 1980) followed by steam distillation (Bremner, 1965).

The incubation study was conducted using close-dynamic air flow system (Ahmed et al., 2006a, b) arranged in a complete randomized design (CRD) with three replications for 19 days. The materials were weighed separately based on treatments before mixing them in a 250 ml conical flask using an orbital shaker at 200 rpm (Yusuff et al., 2009) for 30 min (Shamsuddin et al., 2009). The crude humin used in this study was extracted from composts (rice straw, rice husk, sawdust and oil palm EFB).

The amounts of urea, ERP and MOP used were a scaled down of the recommended fertilizer for maize. Crude humin was applied based on its potassium content. For treatments with humin, the amounts of urea and ERP used were reduced based on nitrogen and phosphorus contents. The treatments evaluated using a 250 g soil were: T0: soil alone, T1: soil + 2.43 g urea, T2: soil + 2.43 g urea + 3.73 g ERP + 1.24 g muriate of potash (MOP), T3: soil + 1.62 g urea + 2.50 g ERP + 26.51 g rice straw humin, T4: soil + 1.79 g urea + 2.85 g ERP + 34.45 g rice husk humin, T5: soil + 1.93 g urea + 3.20 g ERP + 31.61 g sawdust humin and T6: soil + 1.97 g urea + 3.25 g ERP + 21.70 g oil palm EFB humin.

Analysis of variance (ANOVA) was used to detect significant differences among treatments, while Tukey's test was used to compare treatment means using Statistical Analysis System version 9.2 (2008).

RESULTS AND DISCUSSION

The selected chemical and physical properties of the soil used in this study (Table 1) were typical of Bekenu series and they were consistent with those reported by Paramananthan (2000) except for CEC, exchangeable calcium, magnesium and sodium.

Ammonia loss started a day after incubation for T3, T4, T5 and T6. While under T1 and T2, NH_3 loss started on the third day of incubation and there was no NH_3 loss for T0. The maximum NH_3 loss for T6 (16.71%) and T2 occurred on the second and fifth day of incubation, respectively. The maximum NH_3 loss for T3 (13.66%) and T4 (12.54%) were observed on the third day of incubation, while the maximum NH_3 loss for T1 (9.50%) and T5 (7.94%) were on the fourth day of incubation (Figure 1).

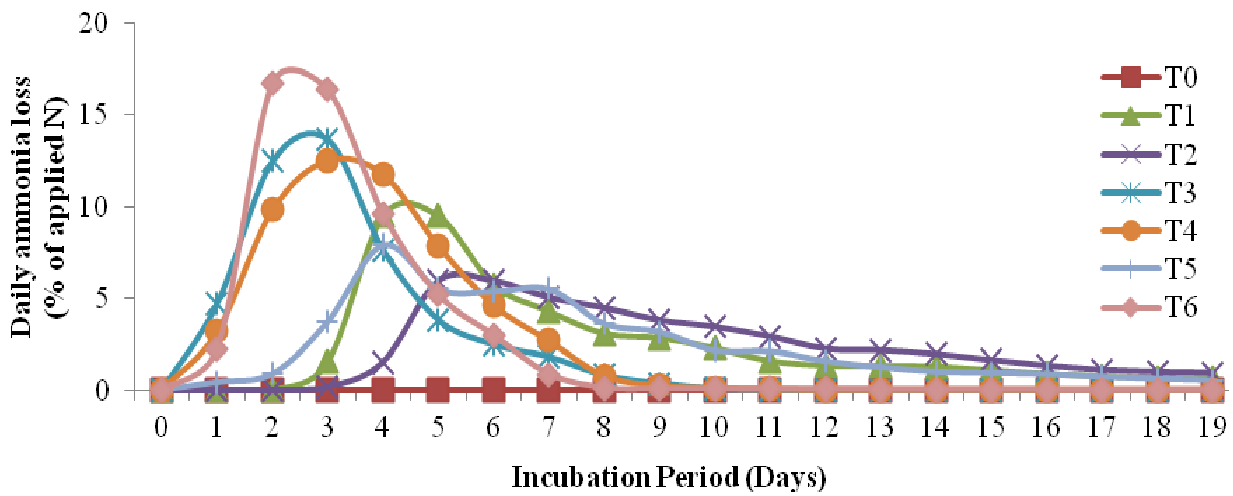

Figure 1. Daily NH_3 loss for different treatments in 19 days incubation period.

Table 2. Total amount of ammonia loss and chemical properties of soil over 19 days of incubation.

Property	T0	T1	T2	T3	T4	T5	T6
Cummulative ammonia loss (%)	0.00^{b}	47.62^{a}	44.86^{a}	47.92^{a}	53.92^{a}	47.67^{a}	54.44^{a}
pH_{water}	4.92^{f}	7.12^{d}	6.71^{e}	7.02^{d}	7.49^{b}	7.82^{a}	7.28^{c}
pH_{KCl}	3.79^{e}	5.88^{c}	5.58^{d}	6.66^{b}	6.97^{a}	6.72^{b}	7.01^{a}
Ash (%)	96.80^{a}	96.33^{a}	96.27^{a}	91.13^{b}	89.80^{c}	88.67^{c}	92.20^{c}
OM (%)	3.20^{c}	3.67^{c}	3.73^{c}	8.87^{b}	10.20^{a}	11.33^{a}	7.80^{b}
TOC (%)	1.86^{c}	2.13^{c}	2.17^{c}	5.14^{b}	5.92^{a}	6.57^{a}	4.52^{b}
Total N (%)	0.06^{b}	0.13^{a}	0.14^{a}	0.20^{a}	0.17^{a}	0.15^{a}	0.16^{a}
Exchangeable NH_4 (mg kg^{-1})	156.45^{c}	945.68^{a}	945.68^{a}	289.54^{bc}	343.25^{b}	410.96^{b}	324.57^{b}
Available NO_3 (mg kg^{-1})	9.34^{b}	21.02^{a}	18.68^{a}	14.01^{ab}	18.68^{a}	18.68^{a}	14.01^{ab}
Exchangeable P (mg kg^{-1})	0.69^{c}	1.63^{c}	258.20^{a}	226.13^{ab}	202.73^{b}	220.53^{ab}	180.73^{b}
CEC (cmol kg^{-1})	11.47^{c}	18.93^{ab}	16.73^{b}	18.17^{b}	20.57^{ab}	23.33^{a}	19.80^{ab}

Different alphabets within a row indicate significant difference between means using Tukey's test at P=0.05.

T2 (urea-ERP-MOP) was able to delay ammonia volatilization compared to other treatments because of phosphoric acid from acidic phosphate hydrolysis, a process which may have reduced urea hydrolysis and ammonia volatilization (Ahmed et al., 2006b). The higher pH and potassium content of crude humin may have increased the soil microsite pH and accelerated urea hydrolysis and ammonia volatilization (Meisinger and Jokela, 2000). This was possible because the treatments with crude humin had the earlier maximum NH_3 loss compared to T1 and T2. Moreover, addition of crude humin had similar effect on total ammonia loss compared to the treatments without humin. The total amount of NH_3 loss and chemical properties of Bekenu series at the end of incubation are shown in Table 2. There were no significant differences in NH_3 loss, total nitrogen and available nitrate content among T1, T2, T3, T4, T5 and T6. Except for T0, all the treatments caused the soil to have neutral pH. However, T4 and T6 caused higher pH_{KCl} compared to others. After 19 days of incubation, T0, T1 and T2 had highest ash content compared to other treatments. T4 and T5 comparably increased organic matter and total organic carbon. T1 and T2 increased exchangeable ammonium. T0 and T1 caused the lowest available phosphorus compared to others. T5 significantly increased CEC. After 19 days of incubation, Bekenu series soil treated with crude humin (T3, T4, T5 and T6) increased exchangeable cations compared to T0, T1 and T2 (Table 3).

Addition of crude humin with high pH, organic matter, total organic carbon, CEC and other nutrients indirectly improves soil chemical properties. This was the reason why the soil treated with T3, T4, T5 and T6 had higher pH, organic matter, total organic carbon, and CEC compared to T2. The pH value and potassium content of the humin were high because 0.1 M KOH was used to isolate humin. Higher organic matter content indirectly reflects higher organic carbon content. Besides, this

Table 3. Exchangeable cations (mg kg^{-1}) of soil over 19 days of incubation.

Exchangeable cations (mg kg^{-1})	T0	T1	T2	T3	T4	T5	T6
K	142.81^{c}	201.54^{c}	1876.64^{b}	1916.58^{ab}	2114.11^{a}	1744.41^{b}	1779.11^{b}
Ca	26.86^{c}	52.43^{c}	869.38^{b}	934.46^{ab}	906.58^{b}	894.40^{b}	1034.28^{a}
Mg	28.68^{c}	28.95^{c}	36.63^{c}	304.30^{a}	288.29^{a}	205.54^{b}	280.28^{a}
Na	29.78^{c}	31.89^{c}	108.46^{b}	132.46^{a}	136.75^{a}	117.57^{b}	111.66^{b}
Fe	19.73^{d}	30.06^{bcd}	26.11^{cd}	35.77^{bc}	32.16^{bc}	39.58^{ab}	47.12^{a}
Cu	0.30^{c}	0.26^{c}	0.28^{c}	0.48^{ab}	0.48^{b}	0.47^{b}	0.54^{a}
Mn	7.46^{d}	4.58^{d}	5.87^{d}	27.43^{b}	40.03^{a}	18.10^{c}	19.68^{c}
Zn	1.70^{d}	1.38^{d}	2.10^{d}	11.78^{a}	10.72^{a}	6.94^{c}	8.65^{b}

Different alphabets within a row indicate significant difference between means using Tukey's test at P=0.05.

higher organic matter content has higher amounts of hydroxylic, carboxylic, and phenolic functional groups which serve as exchange sites and increases CEC of soil (Brady and Weil, 2002).

Exchangeable ammonium under T1 and T2 was higher because of higher amount of urea application. Nitrogen from urea is more readily available due to its higher solubility. Crude humin which are chemically inert and insoluble may release nitrogen slowly for long terms and could serve as slow release fertilizer. The higher amount of ERP in T2 increased P availability in the soil after 19 days of incubation. Application of chemical fertilizers only supplies particular nutrients to the soil, while application of crude humin supplies various exchangeable cations which are available for plant uptake.

Conclusion

Although, crude humin was unable to retain N in the form of ammonium or nitrate ions, it improved soil chemical properties such as pH, organic matter, total organic carbon, CEC, and cations. Thus, the crude humins from different types of composts could be used to amend acid soils but long term field evaluation is essential to consolidate the findings in this study.

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