

Effect of Enhancing Urea-Humic Acid Mixture with Refined Acid Sulphate Soil

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Abstract: Problem statement: Acid Sulphate Soil (ASS) is a problem soil partly because of its high acidity. This low pH could be exploited to reduce ammonia loss from urea by reducing soil microsite pH. The use Humic Acid (HA) to control ammonia loss from urea has been reported but the cost of this material is high. This laboratory study compared the effect of enhancing urea-humic acid mixtures with acid sulphate soil on NH₃ loss, pH, exchangeable ammonium and available nitrate contents. **Approach:** Humic acid, acid sulfate soil and soil used in the incubation study were analyzed for selected soil physical-chemical properties using standard procedures. Urea-HA-ASS mixtures were prepared and ammonia volatilization of the mixtures was evaluated by the closed-dynamic air flow system. The treatments were evaluated in a randomized complete block design with 3 replications. Standard procedures were used to determine ammonia loss, soil pH, exchangeable ammonium and available nitrate at 22 days of incubation. Data obtained were analyzed using analysis of variance and Duncan's test using Statistical Analysis System (SAS) version 9.2. **Results:** Urea amended with 0.75 g ASS significantly reduced ammonia volatilization. Although the use of appropriate amount of acid sulphate soil to control ammonia loss is possible, excessive use of this material is not recommended because of Fe in it. **Conclusion:** Urea amended with 0.75 g ASS reduced ammonia.

Key words: acid sulphate soil, urea, humic acid, ammonia loss

INTRODUCTION

Acid Sulphate Soils (ASS) are extensive in this region^[1,2] A recent study on ammonia loss from urea by using acidic materials such as Humic Acid (HA) has been successful^[3,4]. Besides reducing ammonia loss, the mixture of urea-HA improves plant growth and development^[5]. However, large scale production of HA in Malaysia is still limited as this country imports HA based fertilizers from China and Australia at a high cost^[2].

Considering the low pH and low cost of ASS, the use of ASS may help to reduce the amount of HA in urea-HA mixture. Besides, this approach may help to increase N use efficiency in agriculture. Appropriate amount of HA may also help to chelate heavy metals such as Al, Fe and so on. The objective of this study was to investigate the effects of enhancing urea-HA with ASS on ammonia loss, exchangeable ammonium (NH₄) and available nitrate (NO₃) under laboratory condition.

MATERIALS AND METHODS

The ASS was collected from Kuching, Sarawak (Telaga Air mangrove and Rempagi) at 0-15 cm depth. The soil was air dried, meshed and sieved to pass a 2 mm sieve before it was characterized for selected soil chemical properties such as pH using glass electrode^[6], Cation Exchange Capacity (CEC) by leaching using 1 N ammonium acetate (adjusted to pH 7) followed by steam distillation technique^[7], exchangeable cations (K, Ca, Mg, Na and Fe) by the double acid method and atomic absorption spectrophotometry (A Analyst 800, Perkin Elmer Instruments, Norwalk, CT)^[8].

The HA was isolated from a tropical peat (hemist) soil at 0-25 cm depth using the method described by Susilawati *et al.*^[9,10]. The oven dried yield of HA was expressed as percentage of the weight of soil used. Functional group analysis of the HA was conducted by the method described by Inbar *et al.*^[11]. The level of humification of HA was determined by E₄/E₆ method

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using spectroscopy^[12]. The model of the spectrometer used was Lambda 25 UV/VIS (Shelton, CT, USA). Both dry HA and ASS was meshed again to pass sieve less than 1 mm after which they were used to mix urea^[3].

Urea, HA and ASS mixture was prepared using the method described by Ahmed *et al.*^[3] with some modification where the materials were weighed separately based on the treatments below before mixing them in plastic vials by using reciprocal mechanical shaker (200 rpm for 10 min).

The incubation study was conducted in a closed-dynamic air flow system^[3] in a Complete Randomized Design (CRD) with three replications for 22 days. The treatments evaluated were:

- Soil alone (T1)
- 2.02 g urea alone (T2)
- 2.02 g urea+0.50 g HA+0.50 g ASS (T3)
- 2.02 g urea+0.75 g HA+0.75 g ASS (T4)
- 2.02 g urea+1.00 g HA+1.00 g ASS (T5)
- 2.02 g urea+0.50 g HA (T6)
- 2.02 g urea+0.75 g HA (T7)
- 2.02 g urea+1.00 g HA (T8)

A total amount of 250 g Nyalau series (Typic Paleudults), sandy clay loam in texture (Sampled at UPM Bintulu Sarawak campus) was used in the incubation study to evaluate treatments. The soil was analyzed for field capacity^[8], bulk density^[8], CEC^[7], exchangeable cation (K, Ca, Mg, Na and Fe)^[8], total N^[13], inorganic N (NO₃ and NH₄)^[7] and pH^[6] before and after the incubation study.

Analysis of variance was used to test treatment effects and means were compared using Duncan's test^[14]. The Statistical Analysis System (SAS) version 9.2 was used for this analysis.

RESULTS

The selected chemical properties of the soil (Table 1) were typical of Nyalau series and were consistent with those reported by Paramanathan^[15]. pH and CEC of the ASS were similar to those reported by Shamsuddin^[2] who also give the properties of tropical ASS. The carbon, phenolic, carboxylic and total acidity of HA were comparable with those reported by Schnitzer^[16] and Tan^[17].

The daily loss of NH₃ is shown in Fig. 1. The treatments with urea additives temporary delayed NH₃ loss (Fig. 1) compared to urea alone (T2). Except for T3 and T6, total ammonia loss over 22 days of incubation for the treatments with urea additives was significantly lower (Table 2) than that of urea alone (T2).

Table 1: Selected chemical and physical characteristics of HA, ASS and Nyalau series

Property	ASS	HA	Soil
pH (water)	3.45	nd	4.85
pH (1 M KCl)	nd	nd	3.65
Total organic carbon (%)	nd	55.59	nd
CEC (cmol kg ⁻¹)	40.50	^a	21.25
Carboxylic group (cmol kg ⁻¹)	nd	300	nd
Phenolic group (cmol kg ⁻¹)	nd	220	nd
Total acidity ^a (cmol kg ⁻¹)	nd	520	nd
Total N	nd	nd	0.4132
Exchangeable K (cmol kg ⁻¹)	0.0827	nd	0.8016
Exchangeable Mg (cmol kg ⁻¹)	0.2042	nd	0.0177
Exchangeable Ca (cmol kg ⁻¹)	0.0534	nd	0.0001
Exchangeable Na (cmol kg ⁻¹)	0.9163	nd	0.0280
Exchangeable NH ₄ ⁺	nd	nd	0.1540
Available NO ₃ ⁻	nd	nd	0.1243
Field capacity (%)	nd	nd	75.57
Texture	nd	nd	SCL

HA: Humic Acid; ASS: Acid Sulphate Soil; CEC: Cation Exchange Capacity; SCL: Sandy Clay Loam; nd: not determined; ^a: CEC of humic acid = total acidity

At the end of the study, T3-T8 had similar effect on soil pH even though those for T4, T6 and T7 were significantly higher than that of urea alone (T2). There was no significant effect of T2-T7 and T8 on available nitrate. In terms of exchangeable NH₄, those of T4 and T7 were significantly lower than those of T2-T4 and T8.

The selected exchangeable cations presented in Table 3 show that all the treatments had no significant effect on the concentrations of Ca and Mg. Only K under T4 was significantly higher than that of urea alone (T2). The concentrations of K for the other mixtures were not significantly different from that of urea alone except T7. The Na contents for all of the mixtures were significantly higher than that of urea alone (T2). Except for T3, the concentration of Cu under T4, to T8 were lower compared with urea alone (T2) while for Fe, only that for T5 statistically similar to the concentration of Fe for urea alone (T2). Being the two (T4 and T7) treatments which controlled ammonia loss better, the low exchangeable ammonium under T4 and T7 compared to T2, T5, T6 and T8 suggests temporary improvement in the retention of ammonium under the two treatments.

DISCUSSION

The reduction of total NH₃ loss for T4, T5, T7 and T8 compared with urea alone (T2) was because of the temporary acidic condition at the urea microsite during urea hydrolysis. This observation was consistent with the research of Ahmed *et al.*^[3,18] who also found a

Table 2: Total amount of ammonia loss, soil pH, available NO₃ and exchangeable NH₄ over 22 days of incubation

Treatment	NH ₃ loss	pH water	Available NO ₃ (mg kg ⁻¹)	Exchangeable NH ₄ (mg kg ⁻¹)
T1	0.00 ^e	4.57 ^c	14.02 ^a	28.00 ^d
T2	49.80 ^a	7.23 ^b	21.02 ^a	994.70 ^{ab}
T3	48.20 ^{ab}	7.33 ^{ab}	10.51 ^a	224.20 ^d
T4	33.24 ^{cd}	7.67 ^a	24.52 ^a	693.50 ^c
T5	43.46 ^b	7.31 ^{ab}	21.02 ^a	963.20 ^{ab}
T6	45.29 ^{ab}	7.62 ^a	14.01 ^a	837.10 ^{bc}
T7	31.36 ^d	7.67 ^a	21.02 ^a	697.00 ^c
T8	36.72 ^c	7.39 ^{ab}	14.01 ^a	1099.80 ^a

Note: Different alphabets indicate significant difference between means using Duncan's test at p = 0.05

Table 3: Selected exchangeable cations of Nyalau series over 22 days of incubation

Treatment	Exchangeable (mg kg ⁻¹)					
	K	Ca	Na	Mg	Cu	Fe
T1	79.20 ^a	95.40 ^a	52.00 ^{cd}	116.80 ^a	10.70 ^a	34.10 ^{ab}
T2	62.20 ^c	78.50 ^a	44.80 ^d	107.00 ^a	9.30 ^a	46.40 ^a
T3	60.90 ^c	115.20 ^a	69.80 ^b	127.30 ^a	9.50 ^a	11.40 ^{bc}
T4	70.70 ^b	104.50 ^a	85.80 ^a	131.30 ^a	7.00 ^b	0.00 ^{cd}
T5	60.70 ^c	92.90 ^a	88.90 ^a	125.60 ^a	5.90 ^b	40.30 ^a
T6	62.00 ^c	79.20 ^a	53.60 ^c	105.10 ^a	4.00 ^c	9.60 ^{bc}
T7	54.90 ^d	94.50 ^a	66.20 ^b	111.10 ^a	3.60 ^c	0.00 ^{cd}
T8	62.10 ^c	119.00 ^a	84.20 ^a	123.20 ^a	3.90 ^c	0.80 ^{cd}

Note: Different alphabets indicate significant difference between means using Duncan's test at p = 0.05

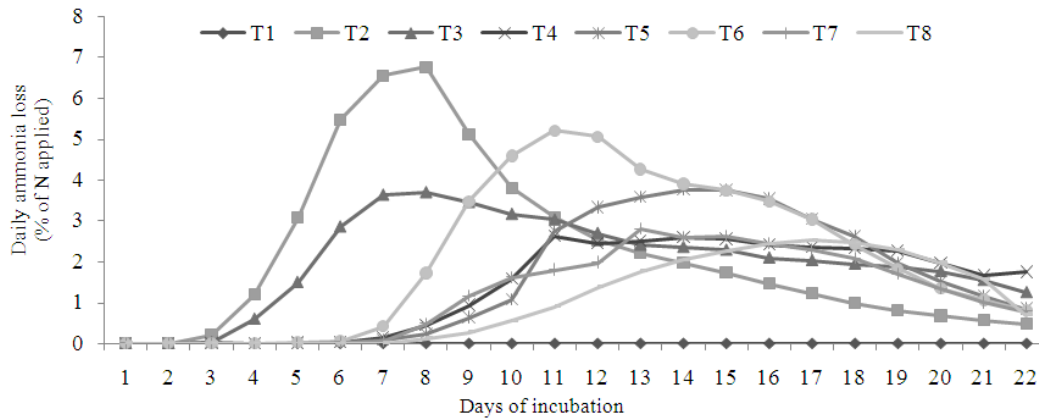


Fig. 1: Daily loss of ammonia from incubation. For key to treatments see materials and method

reduction in NH₃ loss when urea was mixed with HA or TSP. This may have effectively increased the volume of soil with which urea was mixed with and also increased the time required for complete hydrolysis^[4]. But for T3 and T6, the use of ASS and HA had similar effect as compared to T2 because the amounts of HA and ASS used were probably not sufficient to reduce NH₃ loss.

Lack of significant difference in available nitrate regardless of treatment suggests favorable formation of exchangeable ammonium over nitrate as the concentrations of ammonium were generally high for all the treatments except for T3. The low exchangeable ammonium for T3 could be due to high ammonia loss (Table 2).

The significant increase in soil pH for T2, to T8 treatments suggests the occurrence of urea hydrolysis and this could be partly because of consumption of more hydrogen ions. The sharp increase in soil pH could also be due to the soil texture (Table 1).

The mixtures did not generally have significant effect on K, Ca and Mg contents because they were free from these cations unlike Na which may have come from HA. This was because NaOH hydroxide was used for the isolation of the HA from peat. The presence of Na suggests that the HA used in this study was not hundred percent pure. This is understood because even highly purified HA may contain some amount of mineral matter. The lower contents of Cu and Fe of

urea additives compared with urea alone could be attributed to chelation because the HA of the mixtures has the ability to chelate Cu, Fe and Al in particular. The fact that chelation was profound for Fe suggests that the Fe of ASS can be controlled by the presence HA in the treatments.

CONCLUSION

Mixing urea with 0.75g ASS (T4) effectively reduces ammonia loss.

ACKNOWLEDGEMENT

The researchers acknowledge the financial support (Research University Grant Scheme) received from the Ministry of Higher Education, Malaysia via University Putra Malaysia.

REFERENCES

1. Dent, D., 1986. Acid Sulphate Soil: A Base Line for Research and Development. ILRI Publication, Wageningen, The Netherlands, ISBN: 9070260980.
2. Shamsuddin, J., 2006. Acid Sulfate Soils in Malaysia. University Putra Malaysia Press Serdang, Selangor, ISBN: 9832871875, pp: 137.
3. Ahmed, O.H., H. Aminuddin and M.H.A. Husni, 2006. Ammonia volatilization and ammonium accumulation from urea mixed with zeolite and triple superphosphate. *Acta Agric. Scandinavica, Plant Soil Sci.*, 58: 182-186. DOI: 10.1080/09064710701478271.
4. Susilawati, K., O.H. Ahmed, A.M. Nik Muhamad, M.Y. Khanif and M.B. Jalloh., 2009. Effect of organic based n fertilizers on dry matter (*Zea mays* L.), Ammonium and nitrate recovery in acid soil of Sarawak Malaysia. *Am. J. Applied Sci.*, 6: 1282-1287.
5. Y. Fahri and D. Murat, 2008. Effect of humic acid applications on the root-rot diseases caused by *Fusarium* spp. on tomato plants. *Plant Pathol. J.*, 7(2): 179-182. ISSN 1812-5387 DOI: 10.3923/ppj.2008.179.182.
6. Brady, N.C. and Weil, R.R. 2002. The Nature and Properties of Soils. 13th Edn., Pearson Education, Inc., New Jersey, ISBN: 0130167630, pp: 498-540.
7. Keeney, D.R. and D.W. Nelson, 1982. Nitrogen-Inorganic Forms. In: *Methods of Soil Analysis, Part 2*, Page, A.L., Page, A.L., D.R. Keeney, D.E. Baker and R.H. Miller et al. (Eds.), 2nd Edn., Agron. Monogr. 9, ASA and SSSA, Madison, WI., ISBN: 0891180729.
8. Tan, K.H., 1996. Soil Sampling, Preparation and Analysis. Marcel Dekker, Inc., New York, ISBN: 0824796756, pp: 408.
9. Susilawati, K., O.H. Ahmed, A.M. Nik Muhamad and M.Y. Khanif, 2008. Simple method purifying humic acids isolated from tropical hemists (peat soil). *Am. J. Applied Sci.*, 5: 1812-1815.
10. Ahmed, O.H., M.H.A. Husni, A.R. Anuar and M.M. Hanafi, 2005. Determination of minimal duration necessary for the isolation of humic acid contained in composted pineapple leaves. *Fruits* 60: 115-120. DOI: 10.1051/fruits:2005022
11. Inbar, Y., Y. Chen and Y. Harder, 1990. Humic substance formed during the composting of organic matter. *Soil Sci. Soc. Am. J.*, 54: 1316-1323. <http://soil.scijournals.org/cgi/content/abstract/54/5/1316>.
12. Stevenson, F.H., 1994. Humus Chemistry: Genesis, Composition, Reactions. John Wiley and Son, New York, ISBN: 0471594741, pp: 378-486. <http://www.scipub.org/fulltext/ajas/ajas5121812-1815.pdf>
13. Jones, J.B., 2001. Laboratory Guide for Conducting Soil Tests and Plant Analysis. CRC Press, USA., ISBN: 0849302064, pp: 209-212.
14. SAS., 2001. SAS/STAT Software. SAS Institute, Cary, NC., ISBN: 10: 1580258506.
15. Paramanathan, S., 2000. Soils of Malaysia: Their Characteristics and Identification. Academy of Sciences Malaysia, Kuala Lumpur, ISBN: 9839445065.
16. Schnitzer, M. and C.M. Preston, 1986. Analysis of humic acids by solution and solid state carbon-13 nuclear magnetic resonance. *Soil Sci. Soc. Am. J.*, 50: 326-331. <http://soil.scijournals.org>
17. Tan, K.H., 2003. Humic Matter in Soil and the Environment: Principles and Controversies. Marcel Dekker, Inc., New York, ISBN: 0-8247-4272-9, pp: 34-71.
18. Siva, K.B., H. Aminuddin, M.H.A. Husni and A.R. Manas, 1999. Ammonia volatilization from urea as affected by tropical-based palm oil palm effluent (pome) and peat. *Communications. Soil Sci. Plant Anal.*, 30: 785-804. DOI: 10.1080/00103629909370246
19. Tan, K.H., 2000. Environmental Soil Science Second Edition Revised and Expanded. Marcel Dekker, Inc., United States, ISBN: 0824703405, pp: 252.

20. Havlin, J.L., J.D. Beaton, S.M. Tisdale and W.L. Nelson, 1999. Nitrogen. In: Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 6th Edn., Prentice Hall, Inc., Upper Saddle River, New Jersey, USA., ISBN: 0136268064, pp: 86-153.
21. Leung, W.H. and A. Kimaro, 1997. Soil amendment with humic acid and phosphate to promote sorption and retard mobility of zinc. *Virginia J. Sci.*, 48: 252-258.