NITROGEN RECOVERY AS AFFECTED BY FORM AND TIME OF FERTILIZER APPLICATION

Zuhdi S. Wibowo*)

Abstract

The experiment to know the nitrogen recovery as affected by form and time of fertilizer application has been conducted at the Laboratory of Biotechnology of IAEA, Seibersdorf, Austria. The fertilizer used was ammonium sulfate with 1,027% ^{15}N atom exess applied in liquid and solid form. The fertilizer application was done three days before seeding (T_1 and T_2) and two weeks after seeding (T_3 and T_4). Sudangrass was used as test plant which fertilized with rate of 100 kg N ha-1.

The results of the experiment shows that ammonium sulfate applied in liquid form on an alkaline soil with high content of calcium carbonate had undergone a significant lost. This loss was probably due to ammonia volatilization and this could not be avoided although the fertilizer was applied two weeks after seeding.

Introduction

One of the processes which affects the nitrogenous fertilizer recovery is loss of nitrogen from soil in gaseous form by two major mechanisms, ammonia volatilization and denitrification. Ammonia gas may be lost to the atmosphere whenever ammonium compounds are applied to the soil surface and the greatest losses will occur from cal soil at high soil pH (Fenn & Kessel, 1976 cit. Rolston, 1978). Fertilizers such as urea and ammonium sulphate will undergo loss of more than 50% of the amount applied, if precautions are not taken. The best solution for minimizing ammonia loss is to incorporate or place ammonium compounds approximately 10 cm below relatively dry surface soil (Rolston, 1978).

On a dry land farming, loss of nitrogen due to denitrification may not occur except at a particular period when soil oxygen becomes depleted in narrow soil-water content range near saturation.

In this experiment, instead of measuring nitrogen losses to atmosphere by sophisticated equipments (Denmead et al., 1974, 1976, cit. Rolston, 1978), an object of the present experiment was to quantify the recovery of applied ammonium sulphate expressed in % ^{15}N atom excess, nitrogen derived from fertilizer (NdfF) and fertilizer use efficiency (% FUE). The calculations of the above parameters can only be carried out by using isotope techniques and in this case ^{15}N labelled ammonium sulphate was used.

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*)IAEA Follow from BPTK Gambung, Indonesia.

Materials and Methods

The experiment was conducted in the field of the IAEA Seibersdorf Laboratory, Austria, from July 13 to October 9, 1984. The soil characteristics of the field are as follows, pH (H_2O) 8.3 and (Kal) 7.7, texture clay loam with clay content 35.9%, loam content 30.0% and sand content 34.1%, gravel at 0 — 40 cm soil depth 0.2 — 5 mm ranging from 15 — 30%, total nitrogen content 0.3%, humus content 6.76%, $CaCO_3$ content 14.3% and high content of available K and P (Claus et al., 1984).

The fertilizer used in this experiment was ammonium sulphate with 1.027% ^{15}N atom excess applied in solid and liquid form. Application of fertilizer was done first at three days before seeding (T_1 and T_2) and the second at two weeks after seeding (T_3 and T_4) when the young plants had 3 — 4 leaves. The solid form was broadcasted on the plot surface and followed by incorporation into the soil about 5 cm depth. The liquid form was made by dissolving solid fertilizer into 400 ml demineralized water per plot and applied by means of spray on the plot surface. In order to have the same condition with solid application after spraying the soil surface was also worked in. Soon after application of the fertilizers, the field was irrigated about one hour using sprinkler irrigation just to get it homogeneously moist. The rate of application per plot was calculated equal to the amount of 100 kg N/ha. This relatively high rate of application was aimed to keep enough nitrogen supply during the plant growth and a better experimental result.

Sudangrass was seeded at 40 cm inter-row distance and 10 cm interplants distance. The plot size was 1.2 × 1.6 m located close to each other in 0.5 m rectangle distance. The whole experiment therefore consists of 4 treatment (T_1, T_2, T_3, T_4) with 5 times replication. The field was kept clean from weeds during the experimental time and frequently irrigated by means of sprinkler irrigation, 2 — 4 hours a day, depending on the dryness of the field at a particular time.

The plot was harvested on October 9, 1984, and the area harvested per plot 1.2 × 0.9 m after taking into account the plot border. Fresh weight of harvested plant per plot and its subsample was recorded. The subsamples were put dried at 70°C overnight and subsequently the dry weights recorded. After grinding, plant samples were analyzed for ^{15}N and total nitrogen.

Results and Discussion

The figures presented in Table 1 show very clearly that by applying ammonium sulphate in liquid form to such type of soil, the ^{15}N atom excess (%) decreased significantly (LSD 0.05). The ^{15}N atom excess was also used to calculate nitrogen derived from fertilizer (% NdfF) and the fertilizer use efficiency (% FUE).

A significant difference in ^{15}N at. exc. between solid compared to liquid application could be observed when the fertilizer was given before seeding. The soil surface was almost dry at the time of application of liquid form and the fertilizer got therefore into direct contact with time gravels which resulted in ammonia formation.

Table 1. **Fertilizer nitrogen recovery of three month old sudangrass (% ^{15}N at. exc., % NdfF, % FUE) applied with different times and forms of ^{15}N labelled ammonium sulphate.**

Time and form of fertilizer application	% ^{15}N excess	% NdfF	% F.U.E.
T_1 = solid, before seeding	0.294 bcd	28.8 bcd	28.5 bcd
T_2 = liquid, before seeding	0.170 a	16.4 a	13.9 a
T_3 = solid, after seeding	0.287 bc	28.0 abc	25.2 abc
T_4 = Liquid, after seeding	0.228 ab	22.4 ab	17.2 ab
LSD 0.05	0.117	11.5	13.2

The same letter on the figures refers to no significant difference at LSD 0.05.

Same trend in ^{15}N at. exc. was found between solid and liquid application two weeks after seeding. However, this was not statistically significant.

From the record of dry matter yield, it could lead to misinterpretation because of its unsensitivity compared to the figure on nitrogen fertilizer yield as shown in Table 2.

Table 2. **Dry matter yield (ton/ha) and nitrogen fertilizer yield (kg/ha) of three month old sudangrass applied with different times and forms of ^{15}N ammonium sulphate.**

Time and form of application	Dry matter yield (ton/ha)	N fertilizer yield (kg/ha)
T_1 = solid, before seeding	5.0 abc	28.5 bcd
T_2 = liquid, before seeding	5.4 bcd	13.9 a
T_3 = solid, after seeding	4.9 ab	25.2 abc
T_4 = liquid, after seeding	4.3 a	17.2 ab
LSD 0.05	1.06	13.2

Conclusion

Ammonium sulphate applied in liquid form on an alkaline soil with high content of calcium carbonate has undergone a significant loss. This loss was probably due to ammonia volatilization and this could not be avoided although the fertilizer was applied two weeks after seeding.

References

1. Rolston, D.E., (1978) Pratt, P.F. (ed.), *Volatile losses of nitrogen from Soil, Management of nitrogen in irrigated agriculture.* New York, 169 — 191.

2. Broeshart, H., (1974) Quantitative measurement of fertilizer uptake by crops. *Neth. J. Agric. Sci.*, 22 : 245 — 254.

Appendix 1. Data obtained from the field and laboratory (Exp. XIII/84 — Wibowo)

Treatment	Rep.	Fresh w.h. plant	DM Yield/ha	% N	N Yield/ha	% ^{15}N a.e.	NdfF % F.U	
	1	3.282	4907	2.14	105.0	0.367	0.36	37.8
	2	2.723	4283	2.36	101.1	0.309	0.30	30.3
	3	3.720	6255	1.52	95.1	0.325	0.32	30.4
	4	3.499	5572	2.07	115.3	0.326	0.32	36.9
	5	2.390	4027	1.26	50.7	0.142	0.14	7.1
$\bar{X}$								28.5
T_2	1	3.345	5382	1.68	90.4	0.275	0.27	24.4
	2	3.126	4894	1.73	84.7	0.310	0.30	25.4
	3	2.424	4212	1.13	47.6	0.052	0.05	2.4
	4	3.347	5432	1.84	99.9	0.054	0.05	5.0
	5	3.897	6877	1.17	80.5	0.158	0.15	12.1
$\bar{X}$								13.9
T_3	1	3.284	4868	2.41	117.3	0.275	0.27	32.7
	2	2.869	4582	1.75	80.2	0.373	0.36	28.9
	3	3.187	5137	1.99	102.2	0.286	0.26	28.6
	4	3.204	4888	1.98	96.8	0.239	0.23	22.3
	5	2.681	4798	1.16	55.6	0.264	0.26	14.4
$\bar{X}$								25.2
T_4	1	2.775	4128	1.99	82.1	0.311	0.30	24.6
	2	3.294	4876	2.02	98.5	0.261	0.26	25.6
	3	1.816	2924	1.34	39.2	0.141	0.14	5.5
	4	2.924	4805	1.82	87.4	0.143	0.14	12.2
	5	2.775	4725	1.38	65.2	0.286	0.28	18.3
$\bar{X}$								17.2

^{15}N at. exc. of fertilizer — 1.022% with rate 100 kg N/ha.