EVALUATING AMMONIUM CHLORIDE AS NITROGEN SOURCE FOR RICE PRODUCTION—APRELIMINARY STUDY

by

M. Aslam Mian and Mohammad Khalid*

ABSTRACT

This paper reports results of a preliminary study from a long term experiment on rice. Basmati–370 was grown on a calcareous sandy clay loam soil in order to assess the relative effectiveness of ammonium chloride compared with ammonium sulphate and urea, each applied at the rate of 75 and 150 kg N/ha. In the same permanent layout wheat followed rice with N application rates of 100, 200 kg/ha in respective carriers. Irrespective of rate, N fertilizers significantly increased the ear bearing tillers/hill, number of grains per panicle and straw yield. This increase was well marked in the case of ammonium chloride and ammonium sulphate compared with urea. The N sources at their respective rates produced statistically equal paddy yield except urea at 75 kg N/ha which was significantly less effective among the fertilizer treatments.

Maximum N uptake and percent N of rice plant were recorded in the case of ammonium chloride followed by ammonium sulphate and urea. Increasing N application in each of the N carriers in general, had a depressing effect on percent P and K in both rice paddy and straw. Although ammonium chloride application caused a significant increase in the Cl contents of paddy and straw, it did not alter the absorption of other mineral constituents in the plant.

The grain yield of wheat following rice did not show significant differences among fertilizer treatments. Though the highest Cl content of soil after harvesting wheat was found in the case of ammonium chloride application, much of it had disappeared probably through leaching.

INTRODUCTION

Considering the quantity being used for enhanced crop production and manufacturing costs involved, nitrogen occupies a key position among fertilizer nutrients used in agriculture.

In the manufacture of caustic soda from sodium chloride in Ittehad Chemicals, Kala Shah Kaku, Cl/HCl are obtained as by products wihich create serious disposal problem and go waste at present. The problem will aggravate further by the setting up of additional caustic soda plants. However, this hydrochloric acid by reaction with ammonia can be converted into substantial quantities of ammonium chloride to serve as a nitrogen fertilizer.

Several investigators have shown ammonium chloride to be similar or superior to other nitrogen sources for rice and other field crops production (Harada, 1952; Ghosh, 1961; Relwani and Ghosh, 1963; Engelstad, 1967; Vyshinskii et al., 1971; Shirenko, 1974). George et al. 1962 observed that under conditions of well drained soils, nearly all chloride applied to soil was lost by leaching within

* Department of Soil Science, University of Agriculture, Faisalabad.

one year. They further reported that nitrogen contents of corn were increased with ammonium chloride more than ammonium sulphate. Carel (1964) found that chloride did not accumulate in soil and its leaching was liable to cause loss of calcium.

Timm and Riekels (1964) in a green house experiment on a highly organic mineral soil of pH 8.2 with high cation exchange capacity and low phosphorus level, observed that uptake of phosphate, sulphate and nitrate by plants were lower in the presence of chloride.

Pakistan soils are inherently impregnated with chloride ions, therefore, ammonium chloride cannot be used as fertilizer for crops such as tobacco and potatoes whose quality is impaired by an excess of chloride (Dunn and Rost, 1948; Garner et al., 1930; Harward et al., 1956). However, its posibility of use as nitrogen source for crops like rice and wheat needs to be tested and this paper reports results of a similar type of experiment.

MATERIALS AND METHODS

A field experiment was conducted on rice. Basmati–370 grown on a normal calcareous sandy clay loam soil of pH 7.7, ECe 1.3 S/cm at 25^{O}CK and Cl content 159 ppm, 37.4 ppm respectively in the surface soil. Three N sources i.e. ammonium chloride, ammonium sulphate and urea were applied @ 75 and 150 kg N/ha . A blanket application of 60 kg P_2O_5 as single super–phosphate (SSP) was done before planting the rice crop. In the same permanent layout wheat followed rice with N application rates of 100 and 200 kg/ha in respective carriers. The experimental layout was Randomized Complete Block Design with seven treatments including control, each replicated four times.

Rice was transplanted on 25th August, 1981 with row to row and hill to hill distance of 25 cm and 20 cm, respectively thus attaining a plant population of 200,000 per hectare. Growth characteristics were recorded and at maturity rice was harvested on Ist December, 1981 and late wheat variety Sonalika sown on December 22, 1981 in the same layout and its grain yield recorded.

Soil samples (drawn before transplanting rice), rice grain and straw were analysed chemically according to methods as outlined in Handbook No. 60 (U.S. Salinity Laboratory Staff, 1954). Nitrogen in soil and plant was determined by Gunning and Hibbard method of sulphuric acid digrestion and distillation was made, respectively with macro and micro–kjeldahl apparatus. Soil available P and K were extracted, respectively with 0.5 M sodium bicarbonate and 1N neutral ammonium acetate and determinations made colorimetrically and flame photometrically respectively.

RESULTS AND DISCUSSION

Yield and yield components

N application had positive effect on yield components and paddy yield of Basmati 370(Table 1). All the three N sources at 150 kg/ha and $(NH_4)SO_4$ at 75 kg/ha N application rate produced similar but higher number of ear bearing tillers, whereas, NH_4Cl and urea at 75 kg/ha rate gave lower number of ear bearing tillers as compared to control.

As regard the average number of grains/panicle, the three N sources and their rates except low rate of urea, caused significant increase in this attribute and the differences among themselves, however, were nonsignificant (Table 1). The pattern of increase in number of grains/panicle is quite in line with the paddy yield of the crop (Table 1).

Both the N application rates of the three fertilizers except 75 kg/ha N as urea gave statistically equal but higher paddy yield than the 75 kg N rate as ureas which in turn was superior to control. In general, paddy yield data is consistent with the ear bearing tillers, number of grains /panicle and the 1000

TABLE–1.

EFFECT OF NITROGEN RATES AND SOURCES ON YIELD AND YIELD COMPONENTS OF RICE (MEAN OF FOUR REPLICATIONS).

N treatment		Av. No. of	Av. No. of	1000 grain	Yield (t/ha)	
Source	Rate (Kg/ha)	ear bearing tillers/hill	grains/ panicle	wt. (g)	Paddy	Straw
Control	0	8.6 d	63.91 c	17.50 e	1.775 c	4.551 e
Urea	75	14.3 c	81.16 b	19.24 d	3.007 b	8.855 d
NH_4Cl	75	15.6 bc	87.78 ab	19.52 cd	3.370 a	9.855 c
$(NH_4)_2SO_4$	75	17.2 ab	90.84 a	20.98 b	3.442 a	9.600 cd
Urea	150	17.9 a	93.91 a	21.34 b	3.551 a	10.267bc
NH_4Cl	150	18.2 a	95.19 a	22.12 a	3.599 a	12.408a
$(NH_4)_2SO_4$	150	17.0 ab	88.97 ab	20.08 c	3.382 a	10.944b

Means followed by the same letter (s) within columns are statistically alike at 5% level of significance.

grain weight. These results are in agreement with the data reported by Harada (1952), Engelstad (1957) and Shirenko (1974). Low response of 75 kg N as urea might be attributed to greater—N loss through volatilization as shown by Ventura and Yoshida (1977). Nonsignificant differences in paddy yield between 75 kg and 150 kg N rate in the case of NH_4Cl and $(NH_4)_2$ SO_4 may be ascribed to the tall nature of rice Basmati 370 which does not give pronounced response to higher level of N fertilization.

N contents of rice plant

N concentration of both paddy and straw significantly increased with the increase in N application, rate of the N sources and this increase was more pronounced in the case of NH_4Cl and $(NH4)_2$ SO_4 compared to urea (Table 2). Efficiency of N utilization as revealed by the apparent N recovery values, was found to be maximum in the case of NH_4Cl foll followed by $(NH_4)_2$ SO_4. Thus Cl content of NH_4Cl had no deleterious effect on N conents of paddy. Teater et al. (1960) also reported similar results. George et al. (1962) showed that with the application of NH_4 Cl, N uptake by forages was more than $(NH_4)_2$ SO_4. The effect of enhanced N absorption in rice by the application of NH_4Cl can be explained on the basis of cation-anion equivalent constancy concept according to which an increase in absorption of any one anion results in reduction in absorption of some other anion or anions, or increase in uptake of one or more cations as reported by Kretschmer et al. (1953). Since rice absorbs preferably NH_4—N, it might have resulted in greater absorption of NH_4 + by the application of NH_4Cl.

P.K and Cl contents of rice

In general, increasing level of N application in the form of three N carriers, apart from some fluctuations, had a depressing effect on percent P and K in both rice paddy and straw (Table 3). However, the differences for K contents were nonsignificant. Reduction in plant P may be attributed to growth dilution effect caused by greater biomass **production** resulting from N fertilization. Though NH_4**Cl** application caused a significant increase in the Cl contents of paddy and straw, yet still lower than toxicity limits of 1.85 to 2.12% (Chapman, 1966) and it did not alter the absorption of other mineral constituents in the plant. This, in general, agrees with the findings of Teater et al. (1960).

Wheat yield and Cl content of soil

Both the N levels of the N sources produced grain yields statistically equal but significantly higher than the control (Table 4), revealing no adverse effect of Cl on wheat yield.

Accumulation of Cl in soil under repeated high applications of NH_4Cl would be undesirable. The 175 kg of N per hactore in the form of NH_4Cl applied to rice and wheat in the present study, added about 444 and 888 kg of Cl per hectare, respectively. The data in Table 4 indicate that the Cl content of the top soil after harvesting wheat was 28.6 and 35.2 ppm, respectively for the two rates of NH_4Cl application demonstrating substantive amounts of Cl having been leached to the lower substrata of the profile. However, the study is continuous and the data are not conclusive. It is proposed to continue the experiment over a period of at least five years. As soon as data from long term effect of fertilizers become available, it will be published.

A germination study on rice was also made in the laboratory on a sandy clay loam and loamy sand soil using N application rates ranging from 0 to 300 ppm in four N carriers (data not presented). Germination count did not reveal any phytotoxic effect of NH_4Cl, though diammonium phosphate was observed to cause some depressive effect on germination.

LITERATURE CITED

1. Carel, P. 1964 Chlorine in Agriculture. Bull. Ecole nat. Super. Agric.

TABLE–2.

EFFECT OF NITROGEN RATES AND SOURCES ON NITROGEN CONTENTS OF RICE.

0

N treatment Source	Rate (kg/ha)	N(%) Paddy	N(%) Straw	N uptake by rice (kg/ha)	Apparent N recovery(%)
Contorl	0	0.788 d	0.306 e	28.01 e	–
Urea	75	0.875 c	0.394 d	61.49 d	44.96
NH_4Cl	75	0.980 b	0.490 b	81.41 c	71.19
$(NH_4)_2SO_4$	75	0.910 bc	0.446 c	74.30 c	61.71
Urea	150	1.068 a	0.508 b	90.04 b	41.35
NH_4Cl	150	1.138 a	0.578 a	112.65 a	56.43
$(NH_4)_2 SO_4$	150	1.103 a	0.551 a	97.87 b	46.57

Means followed by the same letter(s) within columns are statistically alike at 5% level of significance.

TABLE–3.

EFFECT OF NITROGEN RATES AND SOURCES ON P,K AND Cl CONTENTS OF RICE.

N treatment		P(%)		K(%)		Cl(%)	
Source	Rate (kg/ha)	Paddy	Straw	Paddy	Straw	Paddy	Straw
Control	0	0.352 a	0.123 a	0.348 NS	0.905 NS	0.195 c	1.218 c
Urea	75	0.314 ab	0.100 abc	0.332	0.834	0.185 c	1.209 c
NH_4Cl	75	0.323 ab	0.078 bc	0.331	0.889	0.253 b	1.306 b
$(NH_4)_2SO_4$	75	0.308 ab	0.123 a	0.347	0.863	0.195 c	1.209 c
Urea	150	0.272 b	0.063 bc	0.320	0.788	0.204 c	1.228 c
NH_4Cl	150	0.275 b	0.058 c	0.319	0.823	0.302 a	1.374 a
$(NH_4)_2SO_4$	150	0.268 b	0.103 ab	0.333	0.814	0.204 c	1.228 c

NS = Nonsignificant.

Means followed by the same letter (s) within columns are statistically alike at 5% level of significance.

Pakistan J. Soil Sc. 1(3) 1-80 (1985)

TABLE–4.

EFFECT OF NITROGEN RATES AND SOURCES ON GRAIN YIELD OF WHEAT AND Cl CONTENT OF SOIL AFTER WHEAT HARVEST.

N treatment		Grain yield (t/ha)	Cl content of soil (ppm)	
Source	Rate (kg/ha)		0–15cm	15–30cm
Control	0	1.179 b	22.1 c	23.5 c
Urea	100	2.306 a	27.0 b	26.7 c
NH_4Cl	100	2.433 a	28.6 b	33.8 b
$(NH_4)_2SO_4$	100	2.484 a	26.0 b	26.3 c
Urea	200	2.066 a	23.2 c	24.5 c
NH_4Cl	200	2.2319 a	35.2 a	42.7 a
$(NH_4)_2SO_4$	200	2.332 a	22.9 c	23.1 c

Means followed by the same letter(s) within columns are statistically alike at 5% level of significance.

Tunis 4: 25–32. (Soils & Fert. Absts. 28(1): 400, 1965).

2. Chapman, H.D. 1966 Diagnostic Criteria for Plants and Soils. Univ. Calif. USA. p. 108.

3. Dunn, L.E. and C.O.Rost 1948 Effect of fertilizers on the composition of potatoes grown in the Red River Valley of Minnesota. Soil Sci.Soc. Amer Proc. 13:374–379.

4.. Engelstad, D.P. 1967 Nitrogen sources for rice in flooded soils. T.V.A. Muscle Shoals, Alabama. (Soils & Fert. Absts. 32(2):105, 1969).

5. Garner, W.W. J.E. Mc Murtrey, J.D. Bowling and E.G.Moss 1930 Role of chlorine in nutrition and growth of the tobacco plant and its effect on the quality of the cured leaf. J.Agr. Res. 40: 627–649.

6. George,W., Meclure Jr. and A.S. Hunter 1962 Investigation of NH_4Cl as a nitrogen fertilizer for forage crops and corn. Agron.J. 54: 443–447.

7. Ghosh, S.K. 1961 Relative response of NH_4Cl and other nitrogenous fertilizers as top dressing for different crops on West Bengal Soils. Proc. Nat. Acad. Sci. India, 31A: 173–183.

8. Harada.T. 1952 Manurial effect of $(NH_4)_2SO_4$ and chloride fertilizers upon growth and yield of rice crop. I.R.C.F.P. /44 Proc. Nat. Acad. Sci. India, 31A:177.

9. Harward, M.E.,W.A. Jackson, L. W. Nielson, J.R.Piland and D.D. Mason 1956 Effects of soil moisture tensions and of chloride and sulphate treatments upon yield, composition and bacterial soft rot of Irish Potatoes. Soil Sci. Soc. Am. Proc. 20:59–65.

10. Kretschmer, A.E, S.J.Toth and F.E. Bear 1953 Effect of chloride versus sulphate ions on nutrient ions absorption by plants. Soil Sci. 76: 193–199.

11. Relwani, L.L. and A.B.Ghosh 1963 Fertilizer value of NH_4Cl and $(NH_4)_2$ SO_4 NO_3 as a source of nitrogen for paddy and wheat. Indian J. Agron.7:206–214.

12. Shirenko, B.K. 1974 Ammonium chloride as a fertilizer for rice crop. J. Indian Soc.Soil Sci. 4:45–47.

13. Teater,R. W.,H.J. Mederski and G.W. Volk 1960 Yield and mineral content of corn as affected by NH_4Cl fertilizer. Agron. J. 52:403–405.

14. Timm,H. and J.W. Riekels 1964 Growth, yield and composition of onion, barley and potato plants, as affected by phosphorus and ammonical nitrogen fertilization. Agron. J.56(5):335-340.

15. U.S.Salinity Lab. Staff. 1954 Diagnosis and Improvement of Saline and Alkali Soils. U.S.D.A. Hand Book No. 60, Washington, D.C.

16. Ventura, W.B. T. Yoshida 1977 Ammonia volatilization from flooded tropical soil. Plant and Soil, 46(3):521–531.

17. Vyshinskii.A.M. M.P.Azakirkova and O.F.Artyushenko 1971 Productiveity of basic agricultural crops to which different forms of nitrogen fertilizer were applied systematically. Agro. Khimiya No.4: 3–8. Soils & Fert. Absts. 34(5):4081, 1971.