

EFFECT OF BIURET CONTENT ON TRANSFORMATION OF UREA NITROGEN IN SOIL

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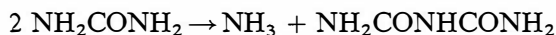
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Summary—The effect of the biuret content (0.0, 1.0, 2.5, 5.0 and 10.0% of urea) on transformations of urea-N was studied in a sandy loam (pH 7.7). While biuret did not affect urea hydrolysis, it inhibited the conversion of NH_4^+ to NO_2^- and the subsequent oxidation of NO_2^- to NO_3^- . This resulted in the accumulation of larger amounts of both NH_4^+ -N and NO_2^- -N in soil as compared to soil receiving urea alone. The results suggest that biuret impurity in urea fertilizer is likely to enhance nitrite toxicity.

INTRODUCTION

Fertilizer urea sometimes contains biuret as an impurity, which is formed during the prilling or granulation of the crystalline urea, when the temperature rises above its melting point.



It has been reported that biuret contamination of urea causes injury to several crop plants, when applied through foliage or soil (Sanford *et al.*, 1954; Jones, 1954; Gasser, 1964; Jain *et al.*, 1972; Bhargava *et al.*, 1974, 1975). Rapid hydrolysis of urea in neutral or slightly alkaline soils causes injury to plants due to ammonia and nitrite toxicity (Court *et al.*, 1962, 1964a, 1964b).

Little, however, is known about how the biuret content affects the transformations of urea-N, particularly in relation to production and accumulation of NH_4^+ -N and NO_2^- -N in soils. The objective of the work reported here was to investigate the effect of biuret concentrations on the transformations of urea-N in soils.

MATERIALS AND METHODS

The soil used was a sandy loam (70% sand, 17% clay) alluvial soil pH 7.7 (1:2.5 soil to water); organic C, 0.58% (Walkley and Black method); total N 0.07% (Kjeldahl method); and cation exchange capacity of 8.9 m.e. 100 g^{-1} soil. The soil analysis was carried out according to the methods described by Jackson (1967). The soil contained $1.5 \text{ parts} \cdot 10^{-6}$ NH_4^+ -N and $8.6 \text{ parts} \cdot 10^{-6}$ NO_3^- -N (Sahrawat and Prasad, 1975). The water holding capacity (w.h.c.) of the soil was 32% (Piper, 1966). The soil was air dried and ground to pass a 2 mm sieve before use.

Analytical reagent grades of both urea (Fischer Scientific Co.) and biuret (Eastman Organic Chemicals, N.Y.) were used in the study.

Samples of 200 g soil were transferred to 500 ml beakers and treated with 5 ml of urea solution in

water containing 20 mg N to obtain $100 \mu\text{g N.g}^{-1}$ soil. Biuret was also applied with suitable aliquots of its aqueous solution to get the desired concentrations of 0.0, 1.0, 2.5, 5.0 and 10.0% on urea weight basis. Urea and biuret in water solutions were first mixed together and then applied to the soil and thoroughly mixed with it. More water was then added to soil to bring its moisture content to 60% w.h.c. The beakers were covered with polyethylene sheets, tied with rubber bands along the rims and incubated at room temperature (mean 28°C , maximum 36°C and minimum 20°C). Water was added to samples to make up the loss due to evaporation twice a week to maintain them at 60% w.h.c.

Duplicate 10 g representative soil samples were drawn from each treatment and analysed weekly for NH_4^+ -N, NO_2^- -N and NO_3^- -N (Sahrawat and Prasad, 1975). Another set of 10 g soil samples were analyzed for urea-N (Douglas and Bremner, 1970). From the NO_2^- -N and NO_3^- -N values obtained from soil analysis, the percentage inhibition of nitrification of urea-N by different concentrations of biuret was calculated from $(C-S)/C \times 100$ where S = amount of $(\text{NO}_2^- + \text{NO}_3^-)$ -N produced in the soil sample treated with biuret and C = amount of $(\text{NO}_2^- + \text{NO}_3^-)$ -N produced in the control (with urea alone, no biuret added) (Bundy and Bremner, 1973).

RESULTS AND DISCUSSION

Results in Table 1 show the effect of different concentrations of biuret on the transformations of urea-N.

Urea-N

Urea hydrolysis was quite rapid and no urea N could be detected in any of the treatments with or without biuret after 1 week of incubation. However, about $9 \text{ parts} \cdot 10^{-6}$ of urea-N was found in all the treatments after 4 days. It is inferred that urea hydrolysis is not affected by biuret content. Bundy and Bremner (1974) also reported that the hydrolysis of urea in the three Iowa, clay loam and sandy loam soils (with pH 6.8, 7.2 and 7.9) was complete in 3 days in an incubation study. Also according to Fisher and

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Table 1. Effect of biuret concentrations on the transformations of urea nitrogen*

Treatment (Biuret concentration % urea wt)		Inorganic N parts $\cdot 10^{-6}$ (or % applied N) after weeks of incubation				
		1	2	3	4	5
0.0	NH ₄ -N	53	30	13	10	4
	NO ₂ -N	4.4	2.8	1.0	0.8	0.0
	NO ₃ -N	30	48	66	78	90
1.0	NH ₄ -N	55	34	15	11	6
	NO ₂ -N	6.2	4.8	2.2	0.8	1.0
	NO ₃ -N	22	40	61	75	88
2.5	NH ₄ -N	61	45	28	16	9
	NO ₂ -N	8.8	5.6	3.7	2.3	1.5
	NO ₃ -N	17	36	52	65	82
5.0	NH ₄ -N	69	51	36	24	12
	NO ₂ -N	14.4	10.3	7.8	6.8	3.0
	NO ₃ -N	9	24	43	56	76
10.0	NH ₄ -N	74	58	43	31	17
	NO ₂ -N	16.0	17.0	14.2	8.8	3.8
	NO ₃ -N	4	13.8	33	50	73

*No urea N could be detected in any of the treatments with or without biuret after 1 week of incubation. About 9 parts $\cdot 10^{-6}$ of urea-N was found in all treatments after 4 days of incubation.

Parks (1958), the hydrolysis of urea is fairly rapid in soils with neutral or above neutral pH and at temperature 20°C or above. The soil used in this study has a pH of 7.7 and the mean temperature of incubation being 28°C, which seems favorable for urea hydrolysis.

Ammonium-N

It is evident from the results shown in Table 1 that application of biuret to urea retarded the conversion of NH₄⁺ to NO₂⁻. Consequently samples with biuret treatments accumulated higher amounts of NH₄⁺-N than those with untreated urea throughout the period of incubation. Accumulation of NH₄⁺-N steadily increased with the increasing concentrations of biuret.

Nitrite-N

The highest amount of NO₂⁻ found in a urea treatment was only 4.4 parts $\cdot 10^{-6}$ at the first week and after 5 weeks no NO₂⁻ could be detected. This figure for NO₂⁻ seems low as compared to those reported by other workers (e.g. Court *et al.*, 1964b; Bundy and Bremner, 1974) but the rate of urea-N used by these workers were many times higher than that used in the present study. Bundy and Bremner (1974) applied urea-N at a rate of 400 $\mu\text{g} \cdot \text{g}^{-1}$ soil and the soils accumulated about 60% of the urea N as NO₂⁻ after 6 days of incubation. But Court *et al.* (1964b) in their studies noted that except in the high rate of urea treatments the amount of NO₂⁻ were very small, being less than 0.5% of the applied N. In the present study however, 4.4% of urea N accumulated as NO₂⁻ after the first week of incubation.

As observed for NH₄⁺-N, biuret treatments also increased the amounts of NO₂⁻ in the soil samples. The highest amounts of nitrites realized from increasing concentrations of biuret (1, 2.5, 5 and 10%) were 6.2, 8.8, 14.4 and 17.0 parts $\cdot 10^{-6}$ respectively (Table 1). The results indicate that with the application of biuret to urea, not only the conversion of NH₄⁺ to NO₂⁻ is retarded but the subsequent oxidation of NO₂⁻ to NO₃⁻ is also inhibited. The inhibition of nitrification of urea-N is further supported by the results shown in Table 2 which indicate that the percentage inhibition of nitrification varied from 18 to 42% with different concentrations of biuret.

Nitrate-N

Nitrification of urea was fairly fast under the experimental conditions and after 5 weeks about 90% of the applied N was in the NO₃⁻ form. Biuret content of urea greatly reduced the rate of NO₃⁻ formation particularly at higher rates. The least amount of nitrates was recorded from 10% biuret treatment. The concentrations of NO₃⁻ in the urea + biuret treatments were always lower than those from urea throughout the incubation. Since most of the N in these treatments were in NH₄⁺ and NO₂⁻ forms, the NO₃⁻ remained low. These results can be further supported by the data in Table 2, pertaining to the inhibition of nitrification of urea-N by different rates of biuret.

The results of the present study indicate that application of biuret inhibited the nitrification of urea N. Both the conversion of NH₄⁺ to NO₂⁻ as well as the

Table 2. Effect of biuret content on nitrification of urea nitrogen

Treatment (Biuret concentration, %)	% inhibition of nitrification after weeks				
	1	2	3	4	5
1.0	18	12	6	4	1
2.5	25	18	17	15	7
5.0	32	32	24	20	12
10.0	42	39	30	25	15

subsequent oxidation of NO_2^- to NO_3^- seem to be retarded by biuret. These results suggest that the NO_2^- toxicity due to urea is likely to be enhanced when the fertilizer has biuret impurities.

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