PLASTIC COATED UREA AS A FERTILIZER SUBSTANCE

by

FRANCISCO A. MEDEROS - APARICIO

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INTRODUCTION

Plant growth is limited more often by deficiency of nitrogen than of any other nutrient.

An ideal nitrogen source is one that releases available nitrogen at a rate that approximates the plants requirements during the growing season, thereby minimizing losses caused by leaching and denitrification. Because of rapid conversions to ammoniacal and nitrate forms, with subsequent leaching losses, standard commercial fertilizers fail to meet this requirement, and a single fertilizer application may not be adequate.

However, if a fertilizer were coated with some material, it might be effective in preventing the rapid release of nitrogen. By varying the thickness of the coating, the plants would obtain a continual supply of nitrogen with a single preplanting application of the fertilizer.

Spencer Chemical Company prepared some urea coated with an unidentified plastic at concentrations of approximately 6 per cent and 12 per cent of plastic material by weight. The main objective of the plastic film is to reduce the rate of ammonification and nitrification of the urea in the soil in order to get a more suitable uptake of nitrogen by plants.

These experiments have been conducted to evaluate the effectiveness of such a coating.

REVIEW OF LITERATURE

The nitrogen utilized by plants is derived primarily from inorganic forms and nitrates are in general considered the most available of the nitrogenuous compounds (5). The entire process is called "mineralization" and probably takes place through the stages:

organic nitrogen → ammonia → nitrite → nitrate

These transformations are primarily brought about in the soil by micro-organisms.

The organic nitrogen → ammonium nitrogen transformation is denoted by the term "ammonification". The process is brought about by a wide variety of micro-organisms, but there is some evidence that ammonia can be produced in soils treated with toluene, and therefore, presumably not by the action of living micro-organisms (24). This transformation is a non-specialized process, although the rapidity of the ammonia formation depends upon the nature of the organisms (33).

The steps ammonium → nitrite → nitrate, however, are carried out by only a few organisms. This transformation is called "nitrification".

As reported by Russel (24), nitrification is mainly a biological process which could be stopped by antiseptics such as chloroform. S. Winogradsky isolated an ammonium oxidizing and nitrate producing bacterium, "Nitrosomonas", and a nitrate forming bacterium, which he named "Nitrobacter" (24). These micro-organisms can synthesize organic compounds using CO_2 as the source of carbon. The necessary energy is derived from the oxidation of nitrogen (5).

The various reactions involved in nitrification of nitrogenous compounds were clearly elucidated in the 1880's. All efforts to isolate the specific organisms responsible for the process failed, however.

The nitrifying organisms, although they appear to be present in all arable land, occur in greater number in fertile than in infertile soils but are never abundant (22). The number of bacteria per gram of soil varies greatly, from a few cells to as many as 24,000 (33).

The activity of the nitrifying bacteria is greatly influenced by soil reaction and environmental conditions, especially temperature, aeration, and moisture supply.

Although nitrogen compounds are present in all cultivated soils, there is seldom enough to promote maximum crop production, and this makes it imperative to use nitrogen compounds as fertilizers.

The use of urea as a fertilizer material is becoming increasingly important in the United States. It is the most concentrated commercially available solid nitrogen carrier, and, by virtue of process improvements, it can now be produced at prices competitive with other solid nitrogen materials (26).

Urea is a white organic compound discovered in 1790 by Roule as a substance occurring in the urine of mammals. Historically it is of considerable interest in that it was the first organic compound to be formed artificially (Wohler, 1828).

Pure urea contains 46.45 per cent of nitrogen. Commercial urea usually contains 45 per cent of nitrogen. It is somewhat hygroscopic and its hygroscopicity increases with rise of temperature. The tendency of urea to absorb atmospheric moisture closely resembles that of sodium nitrate (21).

Urea as a fertilizer material has been commonly considered to be like nitrate in its susceptibility to leaching and to resemble ammonia in transformations following hydrolysis. However, Conrad and Adams (12) conducted some percolation studies with urea solutions and showed that some of the nitrogen from urea was retained. Furthermore, Broadbent, Hill, and Tyler (7) reported that urea moves less rapidly than nitrate in soil columns, and Benson and Barnette (3) did not observe leaching of urea when excess water was applied after four days of incubation period. Most investigators agree in attributing this retention of urea by soils to rapid hydrolysis of urea to ammonia more than to urea being held by adsorption forces in the soil.

Gibson (15) investigated the decomposition of urea in 59 samples of extremely varied character. Urea was decomposed readily in all and very rapidly in most of the samples. He reported that though urea is not absorbed by soils, its rapid conversion to ammonia will generally prevent losses by leaching.

When urea dissolves in water it is converted to ammonium bicarbonate. Under general soil conditions this transformation is complete within three days. The ammonium bicarbonate reacts with the soil acids as quickly as it is formed, the acidity of the soils is thus reduced, and the ammoniacal nitrogen becomes in part chemically held in the soil particles. The ammoniacal nitrogen that is not used by the crops or is removed to a lower depth by leaching may in turn be converted to nitrate nitrogen and the acidity of the soil again increases.

That several kinds of bacteria can transform urea to ammonium carbonate in soils has been amply demonstrated. However, it has been considered by Sumner and Somers (29) that bacteria employ urease to convert urea to ammonia for their needs. Urease was the first enzyme obtained in a pure state.

Conrad, in a series of several papers (8, 9, 10, 11), presented evidence that the hydrolysis of urea should be considered catalytic in nature instead of completely microbial. Rate of hydrolysis of urea in soils sterilized with toluene was only slightly lower than in soils which had not been treated with toluene (8).

According to Conrad (11), the microbial concept of urea transformations in soils is by no means completely ruled out, but the micro-organisms would need to be resistant to toluene and at least some of the strains would need to be thermophilic. Efforts to get any micro-organisms to grow on plates in the presence of toluene have failed.

Fisher and Parks (13) added urea to soil samples at rates equivalent to 100 and 200 pounds of nitrogen per acre. These samples were placed in temperature controlled chambers maintained at 10, 20, and 30°C. Results show that there was generally an increase in the rate of urea hydrolysis and subsequent nitrification with an increase in soil temperature. Conrad (8) reported that Rubentschik found organisms that were capable of decomposing urea below 0°C. In the same paper Conrad reported that urea was hydrolized at 2°C but not at 90°C.

Broadbent, Hill, and Tyler (7) observed that at 45°F 200- and 400-ppm amounts of urea were completely hydrolyzed after seven days of incubation, although some urea remained after three days when the initial application was 400 ppm or less.

The experiment reported herein is a comparative study of rates of ammonification and nitrification of three different types of urea fertilizer in order to evaluate their nitrogen supplying power.

METHODS AND MATERIALS

Soils Used

The surface six inches of two soils were used in this study. A Geary silty clay loam was obtained from the Kansas State University Agronomy Farm near Manhattan, Kansas. This is a well drained, moderately dark colored, moderately fine textured, Reddish Prairie soil which has developed in reddish-brown loess or loess-like materials.

The second soil was a Sarpy fine sandy loam, obtained from the Ashland Agronomy Farm near Manhattan. This alluvial soil is found adjacent to the Kansas River and is suitable for growing corn, hay, and alfalfa.

Fertilizer Material

Three different types of urea were used in this study; regular urea, medium coated urea, and heavy coated urea. These products were prepared by Spencer Chemical Company. The coating is an unidentified plastic and constitutes 6 per cent and 12 per cent of the fertilizer material, in the medium and heavy coated urea, respectively.

Laboratory Analyses of Fertilizer

Total nitrogen in the fertilizer samples was determined by the Kjeldahl method modified to include nitrogen of nitrates according to the procedure reported in "Official and Tentative Methods of Analysis" (2). The results are reported below in percent of nitrogen in the sample.

Table 1. Analyses of Urea Samples.

Fertilizer	Per cent of nitrogen in the sample
Regular Urea	45.3
Medium Coated Urea	43.05
Heavy Coated Urea	40.4

Ammonification and Nitrification Procedures

Both soils, Geary silty clay loam and Sarpy sandy loam, were spread out on a table and thoroughly mixed with the fertilizers. One thousand grams of each soil (on dry weight basis) were placed in 21 pots, thus making a total of 42 pots.

The same treatment was used with all the pots in regard to phosphorus and potassium applications, 200 pounds per acre of phosphorus and potassium in every pot. Normal superphosphate (0-20-0) and muriate of potash (0-0-63) were used for this purpose.

Two rates of regular urea, medium coated urea, and heavy coated urea were applied to the soil, with three replications per rate.

Table 2. Rates of fertilizer application per soil for ammonification and nitrification studies.

Treatments used	Rate of N lbs/A	Rate of N gm/pot	Rate of Urea gm/pot
1. Control	0	0	0
2. Regular Urea	100	0.05	0.1104
3. " "	400	0.2	0.4416
4. Medium Coated Urea	100	0.05	0.1161
5. " " "	400	0.2	0.4645
6. Heavy Coated Urea	100	0.05	0.1237
7. " " "	400	0.2	0.495

On February 1st, 1961, all the pots were placed in a constant temperature room and the temperature was maintained close to 80°F. Variations of only 3 to 5°F occurred during this experiment.

The moisture content of the soil in every pot was maintained at field capacity.

Periodically, soil samples were removed from each of the 42 pots. Toluene was then added to each soil sample to prevent any further action of bacteria. Nitrate and ammoniacal nitrogen determinations were made.

Laboratory Analyses of Soil Samples

Ammoniacal nitrogen was determined by Richardson's modification of Olsen's method, as outlined by Piper (23). The procedure followed in nitrate determination is a modification of Harper's colorimetric Phenolph-disulphonic Acid method (16). This adaptation for photometric determination is reported by Jackson (17).

Greenhouse Procedure

On January 27, 1961, both soils were passed through a half inch screen and the equivalent to 2,750 grams of dry soil was placed in pots. After the soil had been spread on a table, superphosphate, muriate of potash, and urea were applied to each soil; fertilizers and soils were thoroughly mixed. The rates of fertilizers application are shown in table 3 and 4.

Table 3. Basic fertilizer treatment (other than N). Rates of fertilizer application per soil for greenhouse studies.

Fertilizer	Rate of application, pounds of P_2O_5 or K_2O per acre	Amount of fertilizer applied, gm per pot *
Superphosphate, 0-20-0	200	1.375
Muriate of potash, 0-0-63	200	0.4365

* This treatment was applied to every pot.

Table 4. Rates of nitrogen fertilizer application per soil for greenhouse studies.

Fertilizer:	No of pots at each application rate	Rate of N, lbs/Acre	Rate of N, gm/pot	Rate of Urea, gm/pot
Control	4	0	0	0
Regular Urea	4	100	0.1375	0.3035
" "	4	200	0.275	0.607
" "	4	400	0.55	1.214
Medium Coated Urea	4	100	0.1375	0.3194
" " "	4	200	0.275	0.6388
" " "	4	400	0.55	1.2775
Heavy Coated Urea	4	100	0.1375	0.3403
" " "	4	200	0.275	0.6806
" " "	4	400	0.55	1.3612

Andrew oats was the crop grown on each soil. Twenty oat seeds were planted in each of the 80 pots at 1 3/4 inches dept. Moisture level was maintained near field capacity by frequent waterings. Oats were harvested on May 8, 1961, yields were calculated and total nitrogen in plants determined.

Chemical Analyses of the Plant Material

Plants were dried in a forced drying oven at 110°C. Dry weight was recorded and each sample was ground. Total nitrogen was determined by the Winkler's boric acid modification of the Kjeldahl method as reported by Jackson (17). One-gram plant samples were digested by 30 ml. portions of concentrated sulfuric acid. A mixture made up of 10 parts K_2SO_4, 1 part $FeSO_4$ and 0.5 parts $CuSO_4$ was used as a digestion accelerator. To the digest 110 ml. of 12 N NaOH solution was added and distilled. Distillate was collected in 4 percent boric acid solution. This later was back titrated with N/14 H_2SO_4. The results were reported in percent of nitrogen in the sample.

RESULTS AND DISCUSSION

Broadbent, Hill, and Tyler (7) observed that at 45°F 200- and 400-ppm amounts of urea were completely hydrolyzed after seven days of incubation. Similar results have been reported by other workers. In the present experiment, the first sampling was made after 22 days of incubation, therefore, the detection of the peak of ammonification curves was not to be expected. Furthermore, the frequency of the sampling was not adequate for an accurate determination of all of the features of the ammonification and nitrification curves.

However, the objectives in the planning of the experiment and its comparative character (study of differences in nitrogen mineralization in the three urea types) made unnecessary the exact determination of the cited features.

Ammonification and Nitrification Studies

Ammonification in Sarpy Sandy Loam. The first sampling of Sarpy sandy loam reflected a definite increase in ammonification of all urea-treated soil samples as compared to the check. Maximum ammonification recorded, at both rates of nitrogen, corresponds to the first sampling. Then ammonification declined rapidly in the samples treated with 200 ppm of N and very slowly

Table 5. Ammonification in Sarpy sandy loam.

Treatment	NH_4^+ - N, ppm after indicated period			
	22 days	36 days	50 days	66 days
Control	19	21	22	20
Regular Urea - 50 ppm N	43	37	33	28
" " - 200 ppm N	124	112	80	65
Medium Coated Urea - 50 ppm N	45	34	31	29
" " " - 200 ppm N	123	106	85	68
Heavy Coated Urea - 50 ppm N	43	32	31	27
" " " - 200 ppm N	133	100	78	64

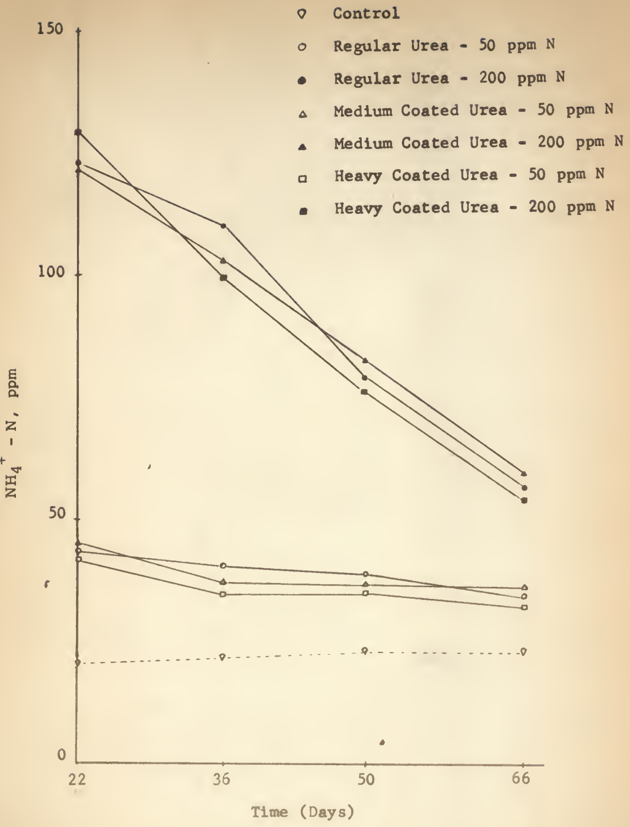

Fig. 1 Rate of ammonification in Sarpy sandy loam.

at the lower rate (50 ppm N). Differences were not noticeable when comparisons of the three types of urea were made.

Ammonification in Geary Silty Clay Loam. With the initial sampling (22 days after start of incubation), there were noticeable differences in the amounts of ammoniacal nitrogen present in the soil depending on which form of urea had been added. Regular urea added at a rate of 200 ppm produced the greatest amount of NH_4^+ (Table 6 and Figure 2). Medium coated urea had released an intermediate amount while the heavy coated urea had released the least. These same general differences existed for the second sampling which was made 36 days after incubation was initiated. However, at the second sampling, the differences between regular urea and medium coated urea, was very small compared to that which existed at the time of the first sampling.

By the time of the third sampling (50 days after incubation was started), the pattern of behavior of the three forms of urea had been reversed. That is to say that regular urea was then showing the least release of NH_4^+ while heavy coated urea was showing the greatest release. This same tendency existed at the final sampling (66 days of incubation). It should be noted that the two coated forms of urea were very similar at the final sampling. These observations prevailed where 200 ppm of nitrogen had been employed.

Where only 50 ppm of nitrogen were added, the three forms of urea behaved rather similarly except possibly at the time of the

Table 6. Ammonification in Geary silty clay loam.

Treatment	NH_4^+ - N, ppm after indicated period			
	22 days	36 days	50 days	66 days
Control	32	33	31	36
Regular Urea - 50 ppm N	71	66	61	65
" " - 200 ppm N	217	185	150	153
Medium Coated Urea - 50 ppm N	79	80	64	86
" " " - 200 ppm N	185	177	161	170
Heavy Coated Urea - 50 ppm N	64	65	60	81
" " " - 200 ppm N	170	164	170	174

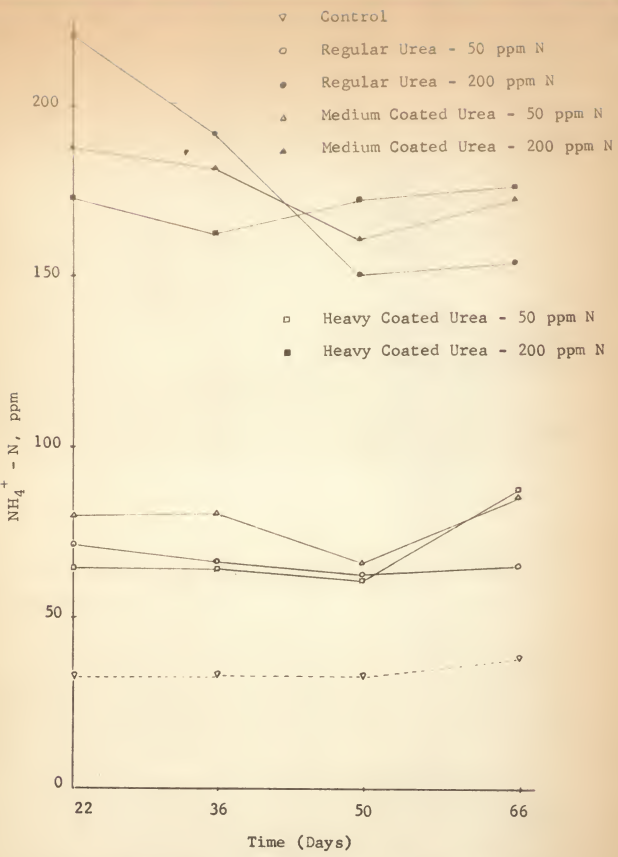

Fig. 2 Rate of ammonification in Geary silty clay loam.

last sampling (66 days after incubation was started). At that time the two-coated urea materials seemed to be releasing substantially more NH_4^+ than regular urea (Table 6 and Figure 2).

It was observed that ammonification of each of the three types of urea occurred at a more rapid rate in Geary silty clay loam than in Sarpy sandy loam. This was indicated by the fact that ammonification curves generally reached a low point at the time of the third sampling of Geary silty clay loam soil. Thereafter, ammonification seemed to remain at a constant rate or possibly it showed a slight increase. However, with Sarpy sandy loam, the amounts of NH_4^+ declined with each sampling, including the final one.

Nitrification in Sarpy Sandy Loam. The second sampling showed a significant difference between nitrification rates in the soil treated with heavy coated urea and the other two where 200 ppm of nitrogen were involved. According to Fig. 3 and Table 7, the heavy plastic coating produced a retarding effect on nitrification at the higher rate of nitrogen addition, during at least the first 36 days of incubation. The third and fourth samplings showed a considerable increase in amounts of nitrates in the samples treated with heavy coated urea at the higher rate. Nitrification rates appeared to be alike for all forms of urea. at the times of the last two samplings. Soils treated with the lower rate of each type of urea showed a decline in nitrification once a maximum was obtained. The higher rate appeared to be still increasing in nitrification when the last sampling was analyzed.

Table 7. Nitrification in Sarpy sandy loam.

Treatment	NO_3^- - N, ppm after indicated period			
	22 days	36 days	50 days	66 days
Control	2.5	5	4.5	5
Regular Urea - 50 ppm N	4	19	21	19
" " - 200 ppm N	3.4	32	30	34
Medium Coated Urea - 50 ppm N	3.8	22	21	20
" " " - 200 ppm N	5	32	33	35
Heavy Coated Urea - 50 ppm N	3.3	19	20	18
" " " - 200 ppm N	4	24	31	36

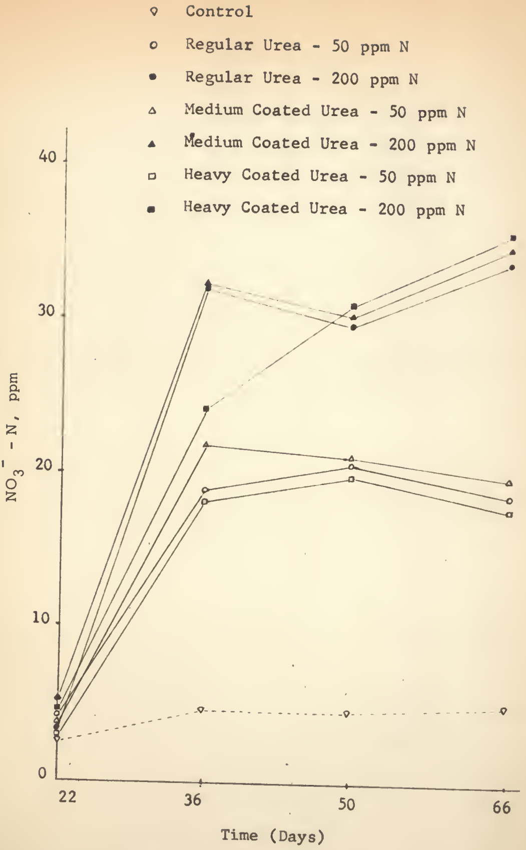

Fig. 3 Rate of Nitrification in Sarpy sandy loam.

Apparently nitrification lagged considerably behind ammonification in this soil. As a matter of fact at the time of the first sampling, the amounts of nitrate nitrogen in soil samples which had received either rate of nitrogen from any of the forms of urea were not materially different from that in the check soil sample.

Nitrification in Geary Silty Clay Loam. Trends of nitrification in Geary silty clay loam were similar to those of Sarpy sandy loam. Probably differences in rates of release of nitrates from the three types of urea were even less important in Geary silty clay loam than in Sarpy sandy loam. Nevertheless, there was a tendency for the heavy coated urea to release nitrate nitrogen more slowly than either regular urea or that with just a medium coating. This was apparent at the second and third samplings. Medium coated urea never fell below either regular urea or heavy coated urea. At the time of the last sampling, heavy coated urea appeared to be releasing nitrates quite readily.

Differences in rates of nitrate release seemed to be relatively more important where only 50 ppm of nitrogen were used. This fact was indicated by comparison of the curves in Figure 4. For example, with the regular urea, peak accumulation of nitrate nitrogen was indicated at or about the time of the second sampling. Thereafter, nitrate accumulation declined rather steadily. However, in the cases of either form of coated urea, nitrate accumulation increased with each sampling. It is doubtful that a peak had been reached even at the time of the

Table 8. Nitrification in Geary silty clay loam.

Treatment	NO_3^- - N, ppm after indicated period			
	22 days	36 days	50 days	66 days
Control	2	5	6	5.5
Regular Urea - 50 ppm N	3.3	10	9	7
" " - 200 ppm N	4	20	18	26
Medium Coated Urea - 50 ppm N	4.2	8	8	10
" " " - 200 ppm N	4	20	21	33
Heavy Coated Urea - 50 ppm N	3	8	7	13
" " " - 200 ppm N	6	17	15	28

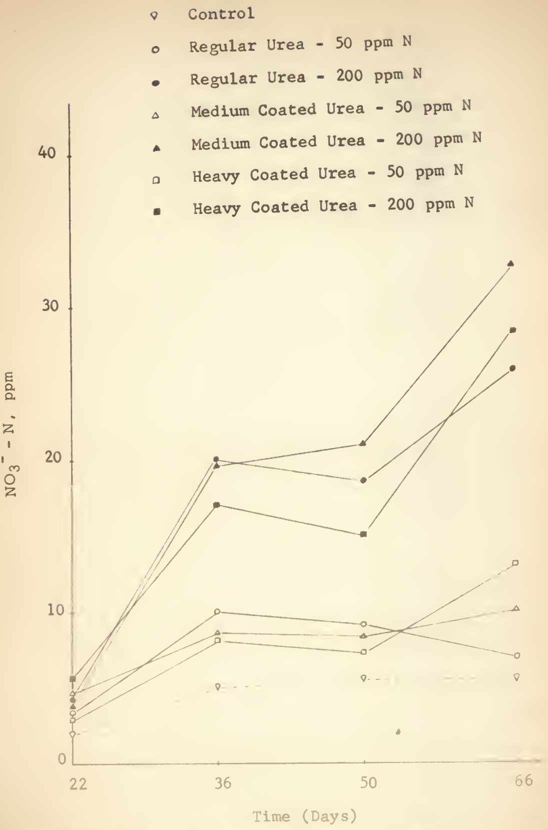

Fig. 4 Rate of Nitrification in Geary silty clay loam.

final sampling. Thus, it appeared that coating of the urea did delay nitrification of urea when such was added at a rate corresponding to 50 ppm of nitrogen.

Studies in the Greenhouse

Yield data were generally variable and inconsistent. With Sarpy sandy loam, regular urea produced higher yields than either of the coated products. Generally speaking, yields were about alike for the two coated materials. However, the best average yield of all was obtained where nitrogen was not used. This behavior was not anticipated because Sarpy sandy loam is very low in total nitrogen content and has been observed to be very nitrogen deficient in the field. Perhaps the marked accumulations of ammoniacal nitrogen which occurred in this soil where urea was added had some adverse effect on plant growth. Thus, poor yields of plant material might possibly be explained.

With Geary silty clay loam, there appeared to be excellent yield responses to applications of urea. Increasing the rate of applied nitrogen to 400 pounds per acre seemed to improve yields in some cases. This seemed especially true where medium coated urea was used. However, the most striking effect of nitrogen was produced where the heavy coated urea was involved. With this type of material the use of only 100 pounds per acre of nitrogen appeared to be as good as either of the higher rates of the same material and essentially as good or better than the highest rate of either of the other materials. Considering only yield data for the Geary silty clay loam soil, it appeared that the heavy coating on urea produced a beneficial effect.

Plant analyses for total nitrogen content showed significant increases with the various applications of urea made to each of the soils. In every case total nitrogen content of plants increased as the rate of application of nitrogen was increased. With Sarpy sandy loam it appeared that the percentage of nitrogen in plants increased as the amount of coating on the urea was increased. This tendency became more evident with the higher rates of application of urea than with the lowest rate. As a matter of fact, it appeared that there was some sort of favorable interaction between rates of application of urea and degree of thickness of the coating on the urea insofar as promoting nitrogen uptake by plants was concerned.

In the case of Geary silty clay loam, the percentage of nitrogen in plants also tended to increase as the amount of coating was increased. However, in contrast with the plants produced on Sarpy sandy loam, those produced on Geary silty clay loam presented less obvious effects of this nature. Furthermore, the effect that did occur was most pronounced at the lowest rate of application of urea whereas with the other soil it was most pronounced at the highest rate of application of urea.

These observations seemed to confirm the results obtained in the nitrification studies. It should be recalled in the case of the nitrification of the heavier rate of urea applied to Sarpy sandy loam, that release of nitrates nitrogen was somewhat reduced at the time of the second sampling but the rate of release rose rapidly and at the time of the final sampling, the material with the heavy coating was releasing nitrate nitrogen at a rate equal to or slightly greater than the other forms. This delayed release of nitrate nitrogen may account for the higher nitrogen content of plant material produced on Sarpy sandy loam soil which was fertilized with the heavy coated urea.

Nitrogen accumulation by plants grown in Sarpy sandy loam did not increase with application of either 100 or 200 pounds per acre of nitrogen from any source of urea. Nitrogen accumulation showed a marked increase with the application of 400 pounds per acre of nitrogen. It may be noted (Table 9) that yields of oats were quite poor with additions of either 100 or 200 pounds per acre of nitrogen to Sarpy sandy loam. Since yields for such additions were substantially below the check yields, the total accumulation of nitrogen by plants was not as large as was true for the check treatment despite the fact that the plants contained a reasonably high percentage of nitrogen. Where 400 pounds per acre of nitrogen were employed yields of oats on Sarpy sandy loam were better than where either 100 or 200 pounds were used and in one instance comparable to that produced on the check. Furthermore, the percentage of nitrogen in such plants was considerable and as a consequence the total accumulation of nitrogen was well above that of the check.

Nitrogen accumulation in plants grown on Geary silty clay loam was more nearly in accordance with what one would expect.

Table 9. Summary of oat yields, Sarpy sandy loam.

Rate of nitrogen, lbs./ A	Yields * for various forms of fertilizer, grams per pot			
	Control	Regular Urea	Medium Coated Urea	Heavy Coated Urea
0	6.87			
100		5.2	3.87	4.0
200		4.9	2.9	3.2
400		6.7	5.36	4.74
Averages for forms		5.6	4.04	3.98

* Yield data represent averages of 4 replications.

Table 10. Summary of oat yields, Geary silty clay loam.

Rate of N (lbs./A)	Yields * for various forms of fertilizer, grams per pot			
	Control	Regular Urea	Medium Coated Urea	Heavy Coated Urea
0	7.55			
100		8.43	8.79	11.45
200		7.8	8.8	11.05
400		9.78	12.3	11.8
Averages for forms		8.67	9.96	11.43

* Yield data represent averages of 4 replications.

Table 11. Nitrogen content of plants, Sarpy sandy loam.

Rate of Nitrogen, lbs./A	Percent of Nitrogen *			
	Control	Regular Urea	Medium Coated Urea	Heavy Coated Urea
0	1.18			
100		1.48	1.52	1.56
200		1.61	1.77	1.76
400		1.92	1.97	2.18

* Nitrogen percentage data represent averages of 4 replications.

Table 12. Nitrogen content of plants, Geary silty clay loam.

Rate of Nitrogen lbs./A	Percent of Nitrogen *			
	Control	Regular Urea	Medium Coated Urea	Heavy Coated Urea
0	1.34			
100		1.57	1.67	1.73
200		1.85	1.94	1.88
400		2.21	2.25	2.27

* Nitrogen percentage data represent averages of 4 replications.

Table 13. Nitrogen accumulation by plants. Sarpy sandy loam.

Rate of Nitrogen, lbs./A	Milligrams of nitrogen per pot			
	Control	Regular Urea	Medium Coated Urea	Heavy Coated Urea
0	81.06			
100		76.96	58.8	62.4
200		78.9	51.33	56.32
400		128.6	105.9	103.3

Table 14. Nitrogen accumulation by plants. Geary silty clay loam.

Rate of Nitrogen lbs./ A	Milligrams of nitrogen per pot			
	Control	Regular Urea	Medium Coated Urea	Heavy Coated Urea
0	101.2			
100		132.0	146.8	198.1
200		144.3	170.7	207.7
400		216.1	276.7	267.8

Accumulation increased with use of each form of urea as the rate of application increased. Furthermore, accumulation by plants seemed to increase as the thickness of the coating increased. This was especially true for use of urea at a rate corresponding to only 100 pounds per acre of nitrogen. It was also somewhat true for the intermediate rate of applied urea (200 pounds per acre), but such apparently was not true for the highest rate of application of urea. Thus, it appeared with the Geary silty clay loam soil that coating of urea had a beneficial effect relative to nitrogen accumulation by oat plants. Such beneficial effect was most noticeable at the lowest rate of application of urea.

Coating of the urea did not seem to aid nitrogen accumulation by plants grown in Sarpy sandy loam. Perhaps the lack of beneficial effect on Sarpy sandy loam was due to an overall deleterious effect of excessive ammoniacal nitrogen rather than to anything directly attributable to the coating itself.

SUMMARY AND CONCLUSIONS

The effects of an unidentified plastic coating of urea fertilizer on ammonification and nitrification were studied. Coated and uncoated urea samples were mixed with two different soils at rates corresponding to 100 and 400 pounds of N per acre. Pots were placed in a constant temperature chamber and samplings were taken every two weeks for analysis. Fertilizers used were regular urea, medium coated urea and heavy coated urea.

Another experiment was conducted in the greenhouse using oats as a test crop. Rates of fertilizer application were 100, 200, and 400 pounds of N per acre. Yields and total nitrogen content of plants were determined.

Yield data were variable and inconsistent. Analysis of nitrification studies data, on the other hand, showed a considerable increase of nitrates in the soil samples treated with heavy coated urea, though not in all cases. Furthermore, there was a significant increase in nitrogen content of plants when heavy coated urea was applied at concentrations of 400 ppm of nitrogen to Sarpy sandy loam.

The heavy coating may have successfully reduced the rate of nitrogen release from urea, but positive conclusions can not be made as to the effectiveness of the plastic coating treatment.

On the basis of results of these experiments the coating treatment of urea did not seem to be definitely effective. However, the apparent theoretical merit of the coating should justify new research in this problem.

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LITERATURE CITED

(1) Anderson, O. E.
The effect of low temperatures on nitrification of ammonia in Cecil sandy loam. Soil Sci. Soc. Amer. Proc. 24: 286-289. 1960.

(2) Association of Official Agricultural Chemists.
Official and Tentative Methods of Analysis. Washington D. C. 1945.

(3) Benson, N. and Barnette, R. M.
Leaching studies with various sources of nitrogen. Jour. Amer. Soc. Agron. 31: 44-54. 1939.

(4) Berge, T. O.
Determination of nitrate nitrogen with a photoelectric colorimeter. Soil Sci. 52: 185-191. 1941.

(5) Black, C. A.
Soil-Plant Relationships. John Wiley & Sons, Inc. New York. 1957.

(6) Brommer, M. M. and Shaw, K.
Denitrification in soils; factors affecting denitrification. Jour. Ag. Sci. 51: 40-52. 1958.

(7) Broadbent, F. E., Tyler, K. B., and Hill, G. N.
Transformation and movement of urea in soils. Soil Sci. Soc. Amer. Proc. 22: 303-307. 1958.

(8) Conrad, J. P.
Hydrolysis of urea in soils by thermolabile catalysis. Soil Sci. 49: 253-263. 1940.

(9) Conrad, J. P.
The nature of the catalyst causing the hydrolysis of urea in soils. Soil Sci. 50: 119-134. 1940.

(10) Conrad, J. P.
The occurrence and origin of urease-like activities in the soil. Soil Sci. 54: 367-380. 1942.

(11) Conrad, J. P.
Enzymatic versus microbial concepts of urea hydrolysis in soils. Jour. Amer. Soc. Agron. 34: 1102-1113. 1942.

(12) Conrad, J. P. and Adams, C. N.
Retention by soils of the nitrogen of urea and some related phenomena. Jour. Amer. Soc. Agron. 32: 48-54. 1940.

(13) Fisher, W. B. Jr. and Parks, W. L.
Influence of soil temperature on urea hydrolysis and subsequent nitrification. Soil Sci. Soc. Amer. Proc. 22: 247-248. 1958.

(14) Frederick, L. R.
The formation of nitrate from ammonium nitrogen in soils : effect of temperature. Soil Sci. Soc. Amer. Proc. 20: 496-500. 1956.

(15) Gibson, T.
Decomposition of urea in soils. Jour. Ag. Sci. 20: 549-558. 1930.

(16) Harper, H. J.
The accurate determination of nitrates in soils. Ind. Eng. Chem. 16: 180. 1924.

(17) Jackson, M. L.
Soil Chemical Analysis. Prentice Hall, Inc., New Jersey. pp. 197-201. 1958.

(18) Jacob, K. D.
Fertilizer Technology and Resources in the United States. Academic Press, Inc., Publishers. New York, N. Y. 1953.

(19) Kinney, G. F.
Engineering Properties and Applications of Plastics. New York. John Wiley & Sons, Inc. 1957.

(20) Meiklejohn, J.
The nitrifying bacteria: a review. Jour. Soil Sci. 4: 59-68. 1953.

(21) Mertz, A. R. and Brown, B.
Production and fertilizer use of urea. U.S.D.A. Circ. 679. 1943.

(22) Miller, C. E.
Soil Fertility. John Wiley & Sons, Inc. New York. 1955.

(23) Piper, C. S.
Soil and Plant Analysis. Interscience Publishers, Inc., New York. PP. 208-210. 1947.

(24) Russel, E. J.
Soil Conditions and Plant Growth. Longmans, Green and Co. LTD. London. 1950.

(25) Sabey, B. R., Bartholomew, W. V., Shaw, R. and Pesek, J.
Influence of temperature on nitrification in soils. Soil Sci. Soc. Amer. Proc. 20: 357-360. 1956.

(26) Sauchelli, V.
The Chemistry and Technology of Fertilizers. Reinhold Publishing Co. New York, N. Y. 1960.

(27) Simonds, H. R.
Source Book of the New Plastics. Reinhold Publishing Co. New York, N. Y. 1959.

(28) Snell.
Colorimetric Methods of Analysis. Vol. 1. D. Van Nostram Co. pp. 624-634. 1936.

(29) Summer, J. B. and Somers, G. F.
Chemistry and Methods of Enzymes. Academic Press, Inc. New York. pp. 154-160. 1947.

(30) Thompson, C. A.
Agronomic Evaluations of Urea-Formaldehyde Concentrate-85 (UFC-85) Solution. M. S. Thesis, Department of Agronomy, Kansas State University. 1959.

(31) Tisdale, S. L. and W. L. Nelson.
Soil Fertility and Fertilizers. The MacMillan Co., New York. 1956.

(32) Von Fisher, W. J. Bobalek, E. G.
Organic Protective Coatings. Reinhold Publishing Co., New York, N. Y. 1953.

(33) Waksman, S. A.
Soil Microbiology. John Wiley & Sons, Inc. New York, N. Y. 1952.

PLASTIC COATED UREA AS A FERTILIZER SUBSTANCE

by

FRANCISCO A. MEDEROS - APARICIO

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High requirement by plants seemingly makes nitrogen the most important element in the soil. Nitrogen deficiency is the main limiting nutrient factor in plant growth.

An ideal nitrogen source would be one that releases available nitrogen at a rate that approximates the plants requirements during the growing season, thereby minimizing losses caused by leaching and denitrification. Because of rapid conversions to ammoniacal and nitrate forms, with subsequent leaching losses, most standard commercial fertilizers fail to meet this requirement, and a single fertilizer application may not be adequate.

However, if a fertilizer were coated with some protective material, it might be effective in preventing the rapid release of nitrogen.

The effects of an unidentified plastic coating of urea fertilizer on ammonification and nitrification were studied. Coated and uncoated urea samples were mixed with two different soils at rates corresponding to 100 and 400 pounds of N per acre. Pots were placed in a constant temperature chamber and samplings were taken every two weeks for analysis. Three different types of urea were used in this study; regular urea, medium coated urea, and heavy coated urea. The plastic coating constitutes approximately 6 percent and 12 percent of the fertilizer material in the medium and heavy coated urea, respectively. All samples of urea were supplied by the Spencer Chemical Company, Kansas City, Missouri.

Another experiment was conducted in the greenhouse using oats as a test crop. Rates of fertilizer application were 100, 200, and 400 pounds of N per acre. Yields, total nitrogen contents, and nitrogen accumulations of plants were determined for the individual cultures.

Yield data were variable and inconsistent. Plant analyses for total nitrogen content showed significant increases with the various applications of urea made to each of the soils. In every case total nitrogen content of plants increased as the rate of application of nitrogen was increased. Percentage of nitrogen in plants also tended to increase as the amount of coating was increased.

Interpretation of nitrification studies data showed a considerable increase of nitrates in the soil samples treated with heavy coated urea, though not in all cases. Furthermore, there was a significant increase in nitrogen content of plants when heavy coated urea was applied at concentrations of 400 ppm of nitrogen to Sarpy sandy loam.

The heavy coating, in particular, may have successfully reduced the rate of nitrogen release from urea, although positive conclusions can not be made as to the effectiveness of the plastic coating treatment.

On the basis of the results of these experiments the coating treatment of urea did not seem to be definitely effective. However, the apparent theoretical merit of the coating should justify new research in this problem.