7-1-1967

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BULLETIN 745 JULY 1967

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NITROGEN SOURCES FOR SMALL GRAIN

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During the past decade the use of urea has been increasing both as a solid and as a component of non-pressure nitrogen solutions for direct application, particularly the latter. The solutions sold in Mississippi usually contain 32% nitrogen. Approximately one-half of the nitrogen is derived from urea and the rest from ammonium nitrate. The solutions are marketed under such trade names as N-Sol-32 and Uran. Because they are highly competitive in price and can be transported, stored, and applied conveniently with a minimum of labor, solutions are gaining in usage and have already become a major source of nitrogen in Mississippi.

Urea is now priced competitively with ammonium nitrate. Fertilizer grade urea usually contains 45% nitrogen, which is 1.34 times as much as is contained by ammonium nitrate. Therefore, less labor is involved in handling urea.

Ammonium nitrate solution has been tested previously by the Mississippi Experiment Station and found to be as effective as ammonium nitrate applied in solid form for the production of oats for grain. Since urea is changed in soils by the enzyme urease to ammonium carbonate (a compound that decomposes to yield ammonia which is volatile), the loss of nitrogen as ammonia gas from urea, or solutions containing urea applied to the surface of the soil does occur under certain conditions, thereby reducing the effectiveness of these fertilizers. Loss of ammonia has been reported greater from soils of neutral to alkaline reaction than from similar soils of acid reaction. This results because the high base content which produces alkalinity also reduces the ammonia holding capacity of the soil.

Urea-ammonium nitrate solution may be applied by spraying or dribbling. Application by spraying in the spring as opposed to dribbling could reduce the response to nitrogen because of "burning" of the foliage by the concentrated fertilizer solution.

Previous experiments have given results which seem to indicate that nitrate sources of nitrogen may be more effective for grain production than ammonium sources. If nitrate were more effective, it would be necessary to apply urea and the urea-ammonium nitrate solution earlier than nitrate sources so that nitrogen could be changed to nitrate by soil bacteria before it is utilized by the small grain during the maturing stage of growth. Urea solution (18% nitrogen) though not available as a fertilizer, was included to measure the influence, if any, of applying urea in solution on its effectiveness as a source of nitrogen.

Experimental Procedure

Based on the considerations just given, experiments to evaluate urea and urea-ammonium nitrate solution as sources of nitrogen for small grain forage and grain production were initiated in the fall of 1959 and continued through the spring of 1966. During this period, experiments were conducted at the Black Belt, Brown Loam, Pontotoc Ridge-Flatwoods, and Northeast Mississippi Branch Stations and at the Central Station at State College. The soil types at each location are shown in Table 1.

[1]Appreciation is extended to R. E. Coats, Superintendent, Black Belt Station; B. C. Hurt, Jr., Superintendent, Pontotoc Ridge-Flatwoods Station; W. J. Gill, Brown Loam Station, and G. B. Welch, Agricultural Engineering Department, State College, for their contributions to this project.

The authors also wish to acknowledge the financial assistance provided by the Mississippi Chemical Corporation Stock Fund Grant.

For forage production, nitrogen was applied at the rate of 40 pounds per acre and for grain at rates of 30 and 60 pounds. Application dates were near March 1, March 15, and April 1 for grain and about March 1 for spring forage. Fall application of nitrogen for forage was made at seeding time which was usually during the period September 15 to October 15. In the fall, both surface and in-soil placement of the nitrogen was employed, but only surface application in the spring. Whether incorporated in the soil or left on the surface, the solid sources of nitrogen were broadcast uniformly over the plots.

Solution sources were applied either as a dribble or as a spray, or both. Dribble applications were made as small streams spaced 12 inches apart across the plots. A 3-gallon, garden-type, compressed air sprayer was used to make the spray application.

Separate experiments were employed for fall and spring forage production and for grain. Each test site received an annual application of 60 lbs. each of phosphate (P_2O_5) and potash (K_2O) per acre which was incorporated during seed bed preparation, except that in a few instances a broadcast surface application was made about March 1 for grain experiments. The various treatments were arranged in a randomized block design with four replications.

In the experiments harvested for grain yield, the plot size was 14 by 75 feet. Yields were obtained by combining a swath through the center of the plot and weighing the grain obtained.

The plot size in experiments harvested

Table 1. Soil types on which experiments were located.

Location	Soil types: Grain tests	Soil types: Forage tests
Black Belt Station	Houston clay	Houston clay
Pontotoc Ridge-Flatwoods Station	Atwood si loam	----------
Brown Loam Station	Grenada si loam	Calloway si loam
	Calloway si loam	Henry si loam
Central Station	Leeper si cl loam	West Point cl loam
Northeast Mississippi Station	----------	Tuscumbia si cl loam

Table 2. Small grain yields as affected by source and rate of nitrogen and time of application.

Nitrogen treatment			Station and bushels of grain per acre				
Pounds per acre	Source[1]	Application time	Brown Loam (5)[2]	Pontotoc Ridge (4)	Black Belt (5)	Central (1)	Weighted average
None	--	----	32	31	36	32	33
30	Ur	March 1	46	45	52	56	49
30	UrSol	March 1	47	45	49	50	47
30	ANUrSol	March 1	41	48	48	56	46
30	AN	March 15	45	53	48	50	48
30	Ur	March 15	46	49	49	46	47
30	UrSol	March 15	46	48	50	49	48
30	ANUrSol	March 15	47	46	45	53	46
60	AN	March 15	56	60	56	56	57
60	AN	April 1	46	55	49	49	50
60	AN	30-March 1 30-April 1	56	60	54	53	56
60	ANUrSol	March 1	49	58	56	68	55
60	ANUrSol	March 15	54	57	57	48	56
60	ANUrSol	April 1	47	57	48	45	50

[1]All nitrogen solutions were applied as a dribble. AN = ammonium nitrates; Ur = urea; UrSol = urea solution; ANUrSol = urea ammonium nitrate solution.

[2]Numbers in parentheses refer to duration of experiment in years.

or forage was 8 by 20 feet. Forage yields vere obtained by clipping a swath 3½ eet wide through the length of each plot vhen the plants were 12 to 18 inches all. The weight of the green forage was ecorded and a sub-sample was taken for noisture and nitrogen determinations. The nitrogen content of the forage was letermined by the Kjeldahl procedure on a composite sample for each treatment and clipping at each location.

Results

Grain yield data for the different locations are shown in Tables 2 and 3. Grain yields were increased by application of nitrogen at all locations and, with comparable dates of application, 60 pounds of nitrogen per acre gave higher yields than 30 pounds. However, the increase for 60 over 30 pounds was not as large as for 30 pounds over none.

Table 3. Small grain yield as affected by source nitrogen. Average of March 1 and March 15 application dates for all locations.

Nitrogen source[1]	Average yield bushel/acre
Ammonium nitrate	48
Urea	48
Urea solution	48
Urea-ammonium nitrate solution	46

[1]Nitrogen applied at the rate of 30 pounds per acre.

Based on the average for all years and locations, each source of nitrogen gave an almost identical increase in grain yield, the exception being urea-ammonium nitrate solution which was slightly less than the others. The differences were not significant statistically, but they reflected a trend which was indicated in the forage experiments as well.

It may also be noted in Table 2 that earlier application of urea and of urea-ammonium nitrate solution than of ammonium nitrate was not required for maximum increases in grain yield from these sources; also, that application as late as April 1 greatly reduced the effectiveness of the nitrogen whether applied as solid ammonium nitrate or as urea-nitrate ammonium solution. Splitting the application of ammonium nitrate —that is applying one-half about March 1 and the rest about April 1—did not increase its effectiveness for grain production over applying it all by or before March 15.

The effect on yield of spraying as opposed to dribbling the nitrogen solution is shown in Table 6. Grain and forage yields were the same for either method of application. Therefore, such additional "burning" of the foliage as may have occurred by spraying the nitrogen solution on did not reduce yields. Although the rate of nitrogen in this comparison was not as high as is recommended for small grain for grains, it is felt that the similar results would have been obtained if the recommended rate had been applied.

In view of the very favorable results obtained with urea, and because of its high nitrogen content and non-corrosive character, this fertilizer probably should gain favorable consideration for top dressing small grain by aerial application.

Forage yields for fall-applied nitrogen are shown in Table 4 along with nitrogen uptake data. As indicated by yield and nitrogen uptake, all sources were about equally effective. Slightly lower yields and nitrogen uptake were obtained with urea-ammonium nitrate solution, but the differences were not significant statistically by the usual techniques of analysis.

The influence of the different sources on yield and nitrogen uptake was unaffected by placement of nitrogen, in the soil or on the surface. Thus it is evident that no substantial loss of nitrogen as ammonia resulted from surface application of urea or urea-ammonium nitrate solution.

At the time the fertilizers were applied

Table 4. Forage yields with different sources of nitrogen applied in the fall.

Nitrogen treatment[1]		Station and forage yield as pounds of dry matter per acre			Weighted average	
Source	Placement	Brown Loam (2)[2]	Black Belt (3)	Central (1)	Dry matter yield lbs./A	Nitrogen uptake lbs./A
None	-----------	787	793	245	700	15
AN	Surface	1232	1210	706	1134	25
AN	In-soil	1262	1268	981	1219	26
Ur	Surface	1386	1164	904	1195	25
Ur	In-soil	1317	1168	961	1185	26
ANUrSol	Surface	1148	1163	807	1092	24
ANUrSol	In-soil	1210	1183	943	1153	25

[1]Nitrogen applied at the rate of 40 pounds per acre. AN = ammonium nitrate; Ur = urea: ANUrSol = urea-ammonium nitrate solution.

[2]Numbers in parentheses refer to duration of experiment in years.

Table 5. Small grain forage yields with different sources of nitrogen applied in the spring.

Nitrogen source[1]	Station and forage yields as pounds of dry matter per acre				Weighted average	
	Brown Loam (5)[2]	Black Belt (4)	Northeast Miss. (4)	Central (3)	Dry matter yield lbs./A	Nitrogen uptake lbs./A
None	3009	2391	2131	1567	2402	26
Ammonium nitrate	4939	3950	2623	3251	4116	40
Urea	5121	4240	3772	3261	4267	41
Urea solution	4447	3619	3298	3195	3760	37
Urea-ammonium nitrate solution	4748	3484	3384	2994	3819	37

[1]Nitrogen applied at the rate of 40 pounds per acre.

[2]Numbers in parentheses refer to duration of experiment in years.

Table 6. Efficiency of urea-ammonium nitrate solution as affected by method of application to small grain.

Nitrogen source[1]	Applied as	Yield in pounds of dry matter per acre: Fall application	Spring application	Oat grain yield—bu/A
Urea-ammonium nitrate solution	Dribble	1054	3898	67
Urea-ammonium nitrate solution	Spray	1091	3982	66
Check	-----------	405	2977	40

[1]Nitrogen applied at 40 pounds per acre for forage and 30 pounds per acre for grain.

in the fall, the surface of the soil was relatively dry, a condition which tends to prevent the enzymatic hydrolysis of urea to ammonium carbonate. With the occurrence of rainfall the unhydrolyzed urea would be washed into the soil where the ammonia would be retained when released following the hydrolysis of urea, thus reducing or preventing its loss.

Forage yields for spring-applied nitrogen are shown in Table 5. Greater differences were obtained among sources in these than in the other experiments. Urea solid gave the largest increases both in yield and in nitrogen uptake, followed by ammonium nitrate, and then the nitrogen solutions, urea and urea-ammonium nitrate. The lower yield and nitrogen uptake associated with the nitrogen solutions apparently are not attributable altogether to loss of nitrogen as ammonia from surface-applied urea because these solutions—particularly the urea solution—were just as effective as ammonium nitrate for grain production when applied t the same time as for spring forage production. Whatever condition was re- ponsible for these differences evidently vas of a temporary nature. Differential esponse to nitrogen sources as was ob- erved here can be caused by difference n positional availability of the nitrogen, nd this may have been a contributing actor. No other explanation seems logi- al.

The experimental sites were located on icid soils at the Brown Loam and Pon- otoc Ridge-Flatwoods Branch Stations ind on neutral to alkaline soils elsewhere. The soil types at each location are shown n Table 1. As may be noted from the yield data which also was confirmed by nitrogen uptake data not given, the per- formance of urea and the nitrogen solu- tions relative to ammonium nitrate was not affected noticeably by soil reaction in these experiments. Under more conducive conditions for hydrolysis of urea, signifi- cant loss of ammonia from the neutral to alkaline soils could have occurred, but such conditions apparently occur rather infrequently during the period when ni- trogenous fertilizers are applied to small grain.

Summary and Conclusions

Field experiments were conducted to compare ammonium nitrate, urea, urea-ammonium nitrate solution, and urea solution for small grain forage and grain production during the period 1959-66.

Urea and ammonium nitrate were found to be equally effective for both forage and grain production, except that urea gave slightly but not significantly higher yields of forage for spring application. In the fall, method of placement of the fertilizer on the surface or in the soil did not affect yield.

On the average, urea-ammonium nitrate solution produced slightly lower yields of grain and forage than did either urea or ammonium nitrate, but the greatest difference occurred with spring application for forage production. In this case an agronomic value equivalent to approximately 80 percent of that of ammonium nitrate was indicated. Urea solution top dressed in the spring gave forage yields similar to those obtained with urea-ammonium nitrate solution, but for grain production it was equal to ammonium nitrate and urea.

The failure of the nitrogen solutions to be as effective as the other nitrogen sources in some cases apparently was not associated altogether with volatilization of ammonia from urea applied to the soil surface. The more logical explanation is that the differences were associated with differences in positional availability which were of a temporary nature.

Application of the nitrogen solutions by spraying as opposed to dribbling did not affect yields, which indicates that "burning" of the foliage was not an important factor affecting response to nitrogen.

Because of its high nitrogen content and non-corrosive properties, solid urea would seem to be particularly suited for aerial application to small grain.

Although some differences were observed among fertilizers, it is concluded that all were satisfactory sources of nitrogen for small grain forage and grain production whether applied in the soil or as a top dressing irrespective of the soil reaction.