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Utilization of Labelled Urea and Ammonium Sulfate by Lowland Rice[1]

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ABSTRACT

Urea and ammonium sulfate are the most common fertilizer N sources used to topdress rice (*Oryza sativa* L.). The high cost of N fertilizer and the possible environmental impact of excess N make it important to obtain good utilization of the fertilizer applied to the crop. The objective of the present investigation was to compare labelled ammonium sulfate and urea in their effect on yield and N utilization in field microplots on Crowley silt loam (typic albaqualf). Nitrogen was applied as an early season topdressing or as a midseason topdressing and the grain and straw yield and recovery of labelled and native N in the grain straw, and soil were measured.

No significant differences in grain and straw yields were observed for the two sources and two times of N application. Ammonium sulfate and urea did not differ significantly in N utilization by the crop. For both sources the recovery of labelled N in the soil-plant system was highest (34 to 55 kg N/ha) in the plots receiving midseason topdressing as compared to the plots receiving early season topdressing (30 to 38 kg N/ha). More native soil N was taken up by the plants during 1976 as compared to the 1975 season.

Additional index words: **Stable isotope, Urea N, Ammonium sulfate N, Topdress, Rice fertilization, Flooded soil.**

AMMONIUM sulfate and urea are the most common fertilizer N sources used to topdress rice (*Oryza sativa* L.). The time of application ranges from immediately after establishment of the rice seedlings to as late as midseason with the fertilizer being applied in single or double applications. Earlier studies by Patrick and Reddy (1976) indicated that approximately one-half of the applied N was recovered in the above ground portion of plants at harvest when the fertilizer N was ammonium sulfate applied at 100 kg N/ha. The applied fertilizer N not recovered in either soil or plant amounted to about one-fourth of the applied N. The experiments reported in the present paper were designed to compare labelled ammonium sulfate and urea fertilizers in their effect on yield and N utilization in field plots. The N sources were applied at slightly lower than the recommended rate in an effort to maximize N utilization. Both early season and midseason topdressings were compared in this study.

MATERIALS AND METHODS

Field experiments were carried out on Crowley silt loam (typic albaqualf) at the Rice Experiment Station, Crowley, La. in 1975 and 1976. The entire field was seeded with 'Vista' rice variety at a rate of 90 kg/ha by drilling in rows 18 cm apart. At the time of seeding 22 kg P/ha and 41 kg K/ha were drilled into the soil. After establishment of seedlings, several small microplots (0.28 m^2) were established using aluminum barriers, such that uniform plant population was obtained in each of the plots. The following topdress treatments were then used:

1. Ammonium sulfate applied as early season topdressing (23 days after seeding).
2. Ammonium sulfate applied as midseason topdressing (50 days after seeding).
3. Urea applied as early season topdressing.
4. Urea applied as midseason topdressing.
5. No applied N (check).

Each treatment was replicated five times and a randomized block design was followed. All plots received 60 kg N/ha either as ammonium sulfate enriched with 5.216 atom percent ^{15}N excess or as urea enriched with 5.006 atom percent ^{15}N excess at early season (23 days after planting) or at midseason (50 days after planting). All plots were kept under continuous flood (7 to 10 cm) for the entire season. The labelled fertilizer N was formed into pellets (4 to 10 mesh) and uniformly distributed on the soil surface.

At the end of the growing season plants were cut at ground level and grain was separated from straw. Five soil cores (10 cm diameter and 15 cm deep) were obtained from each plot to determine the labelled N remaining in the soil. Our earlier work showed this depth to be adequate for recovering fertilizer N (Patrick and Reddy, 1976). Grain and straw (not including roots) and the soil (including roots) were analyzed for total Kjeldahl N (Bremner, 1965a) and for labelled N (Bremner, 1965b). Instead of direct conversion of urea to N_2 as described in the procedure (Bremner, 1965b) it was found necessary to first hydrolyze the urea to ammonium before conversion to N_2. A more complete description of the experimental methods used is given in Patrick and Reddy (1976) and Reddy and Patrick (1976).

RESULTS AND DISCUSSION

Grain and Straw Yields. The grain and straw yields obtained during the 1975 and 1976 seasons are presented in Table 1. There was no significant difference in grain yield between the two sources when applied as early season topdressing, but midseason application of urea was slightly superior to ammonium sulfate in both years. For ammonium sulfate early season and midseason topdressings produced about equal yields, but for urea midseason application was superior to early season application. Grain yields were higher in 1976 than in 1975 for all treatments including the untreated control. In both the years there was significant response to fertilizer N.

For straw production there was little difference in N sources (Table 1). Midseason application produced more straw in 1975 for both N sources while the op-

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Table 1. Yield of grain and straw.

Treatment	Grain†		Straw		Grain/Straw ratio	
	1975	1976	1975	1976	1975	1976
	metric tons/ha					
1. AS—early season topdressing	4.1 b*	6.0 b	4.0 b	8.1 d	1.02	0.75
2. AS—midseason topdressing	4.3 b	6.2 b	4.5 bc	6.3 b	0.96	0.98
3. U—early season topdressing	4.2 b	5.9 b	4.0 b	7.1 c	1.05	0.83
4. U—midseason topdressing	4.6 c	6.5 c	5.0 c	6.5 b	0.92	1.00
5. No applied N	2.8 a	4.1 a	2.9 a	4.3 a	0.96	0.95

* Values followed by the same letter do not differ significantly at 5% level of probability. † Yield expressed on 12% moisture basis.
AS = ammonium sulfate. U = urea.

Table 2. Uptake of total N (soil N + fertilizer N) by grain and straw.

Treatment	Total N					
	Grain		Straw		Total	
	1975	1976	1975	1976	1975	1976
	kg/ha					
1. AS—early season topdressing	40.0 b*	58.3 b	25.1 b	43.0 c	65.1	101.3
2. AS—midseason topdressing	45.0 bc	68.5 c	25.6 b	35.2 b	70.6	103.7
3. U—early season topdressing	40.1 b	55.3 b	23.4 b	37.1 b	73.5	92.4
4. U—midseason topdressing	50.2 c	68.8 c	25.8 b	38.0 b	76.0	106.8
5. No applied N (check)	28.7 a	38.5 a	17.1 a	21.6 a	45.8	60.1

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posite result was obtained in 1976 with early season application being superior.

Nitrogen Uptake at Harvest. There was no significant difference in ammonium sulfate and urea in total uptake of N by grain (Table 2). For total uptake in grain and straw, urea was slightly superior to ammonium sulfate. Both total above ground uptake of N (grain and straw) and uptake by grain alone were higher for midseason application of both sources as compared to early season application. As was the case with grain yields, total N uptake by the crop was considerably greater in 1976 than in 1975.

During the 1975 season the uptake of total N in the grain and straw ranged from 65 to 76 kg N/ha and in the 1976 season the uptake of total N ranged from 92 to 107 kg N/ha. The increased uptake during the 1976 season was probably due to greater mineralization of native soil N in the plots used for that year. When no N was applied to the check plots, the uptake of total N was 45 and 60 kg N/ha, respectively, for the 1975 and 1976 seasons.

There did not appear to be any consistent differences between two sources in recovery of fertilizer N (Table 3 and 4). The uptake of fertilizer N by both grain and straw was considerably greater where N was applied as a midseason topdressing. This was especially true for the 1976 season. In fact, the superiority of a midseason topdressing over an early season topdressing was relatively greater for fertilizer N uptake than it was for grain yield.

Table 3. Recovery of labelled fertilizer N in various components of the plant-soil system in 1975.

N—fraction	Ammonium sulfate—N		Urea—N	
	Early season topdressing	Midseason topdressing	Early season topdressing	Midseason topdressing
	kg/ha			
N—in rice plant	19.8 ± 3.7	24.8 ± 4.2	18.0 ± 1.6	27.5 ± 3.7
grain	12.7 ± 2.5	16.4 ± 3.1	11.5 ± 0.8	18.5 ± 2.3
straw	7.1 ± 1.2	8.4 ± 1.1	6.5 ± 0.8	8.7 ± 1.4
N—remaining in soil (roots + soil)	14.2 ± 3.0	9.4 ± 3.1	12.3 ± 1.8	12.7 ± 2.0
Total applied N recovered	34.0 ± 6.7	34.2 ± 7.3	30.3 ± 3.4	40.2 ± 5.7
N—unaccounted for	26.0	25.8	29.7	19.8

Table 4. Recovery of labelled fertilizer nitrogen in various components of the plant-soil system in 1976.

N—fraction	Ammonium sulfate—N		Urea—N	
	Early season topdressing	Midseason topdressing	Early season topdressing	Midseason topdressing
	kg/ha			
N—in rice plant	18.5 ± 1.9	29.5 ± 2.7	15.7 ± 2.0	29.0 ± 2.9
grain	10.5 ± 1.1	21.3 ± 1.4	9.5 ± 1.2	20.3 ± 2.1
straw	8.0 ± 0.8	8.2 ± 1.3	6.2 ± 0.8	8.7 ± 0.8
N—remaining in soil (roots + soil)	19.0 ± 3.8	21.2 ± 5.2	18.1 ± 5.1	25.9 ± 5.3
Total applied N recvoered	37.5 ± 5.7	50.7 ± 7.9	33.8 ± 7.1	54.9 ± 8.2
N—unaccounted for	22.5	9.3	26.2	5.1

Approximately one-third of the N applied during 1975 as an early season topdressing was recovered in the grain and straw (19.8 and 18.0 kg N/ha for ammonium sulfate and urea, respectively). However, when N was applied as midseason topdressing, increased uptake of N was observed (24.8 and 27.5 kg N/ha for ammonium sulfate and urea, respectively.) During the 1976 season in the plots receiving early season topdressing, 18.5 and 15.7 kg N/ha was accumulated in grain and straw with ammonium sulfate and urea, respectively. When N was applied as a midseason topdressing, the uptake of N by grain and straw at the end of the growing season was 29.5 and 29.0 kg N/ha for ammonium sulfate and urea, respectively. It was hoped that the lower rate of N application used in this study would increase the recovery of the applied N by the grain and straw. The results indicate, however, that the recovery of labelled fertilizer N was lower than that obtained with a higher rate of N application (Patrick and Reddy, 1976). Early season topdressing resulted in greater losses compared to midseason topdressing.

The labelled fertilizer N remaining in the soil is also presented in Tables 3 and 4. During the 1975 season the labelled N remaining in the soil ranged from 9.4 to 14.2 kg N/ha. Ammonium sulfate or urea N did not differ significantly. During the 1976 season approximately one-third of the applied N (18.1 to 25.9 kg N/ha) was recovered in the soil. Midseason topdressing probably resulted in greater immobilization of applied fertilizer N compared to early season topdressing.

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Maximum recovery (ranging from 34 to 55 kg N/ha) of applied fertilizer N in the soil-plant system was obtained when either urea or ammonium sulfate was applied at midseason. When the same rate of N was applied during the early part of the growing season, the recovery of applied N ranged from 30 to 38 kg N/ha in the soil-plant system. Delaying N application until the plant was large enough to rapidly absorb the applied N decreased the likelihood of loss by denitrification, ammonium volatilization, and leaching.

CONCLUSIONS

The results of this study showed that when urea or ammonium sulfate fertilizer N was applied as a topdressing at 60 kg N/ha, the recovery of applied N in the soil-plant system was greatest for midseason application compared to early season application. Grain and straw yields, as well as recovery of N in the soil-plant system, were essentially the same for both sources.

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