Movement of Urea in Soils

downward movement of urea in soils and possibility of loss by leaching dependent on rate of conversion to ammonium form

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Fertilizer urea is considered—usually—to resemble nitrates in its mobility in soils because it is not strongly retained by soil colloids and appears to move freely in the soil solution. However, when added to a soil, urea is converted to ammonium carbonate, and when nitrogen is in the ammonium form it is leached only slightly. The downward movement of urea in soil and the possibility of leaching loss are dependent on the rate of hydrolysis—the conversion of urea to the ammonium form. The hydrolysis is accomplished through the activity of enzymes, present in all agricultural soils, although the rate of conversion varies somewhat among different soils. The accompanying table shows that in four soils the equivalent of 200 pounds per acre urea nitrogen was hydrolyzed to ammonia in two days, and in two of the soils there was virtually no urea remaining after one day. Thus there would be movement of urea nitrogen for only a day or two—or in some soils, only a few hours—because it would be converted to the ammonium form.

Urea Remaining after Addition of 200 Pounds per Acre Urea Nitrogen

Days incubated	Hanford sandy loam	Salinas clay	Yolo loam	Sacramento clay
1	44	0	6	98
2	10	0	0	0
3	0	0	0	0

To determine—for practical situations—the vertical distribution of urea in a soil following an irrigation or a rain, experimental data were obtained on several soils. Urea solutions of known concentration were added to columns of dry soil contained in glass tubes. After varying intervals the columns were cut into short sections to determine how far down the

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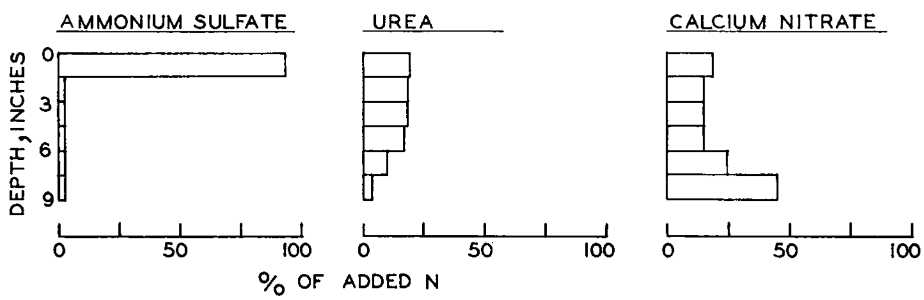
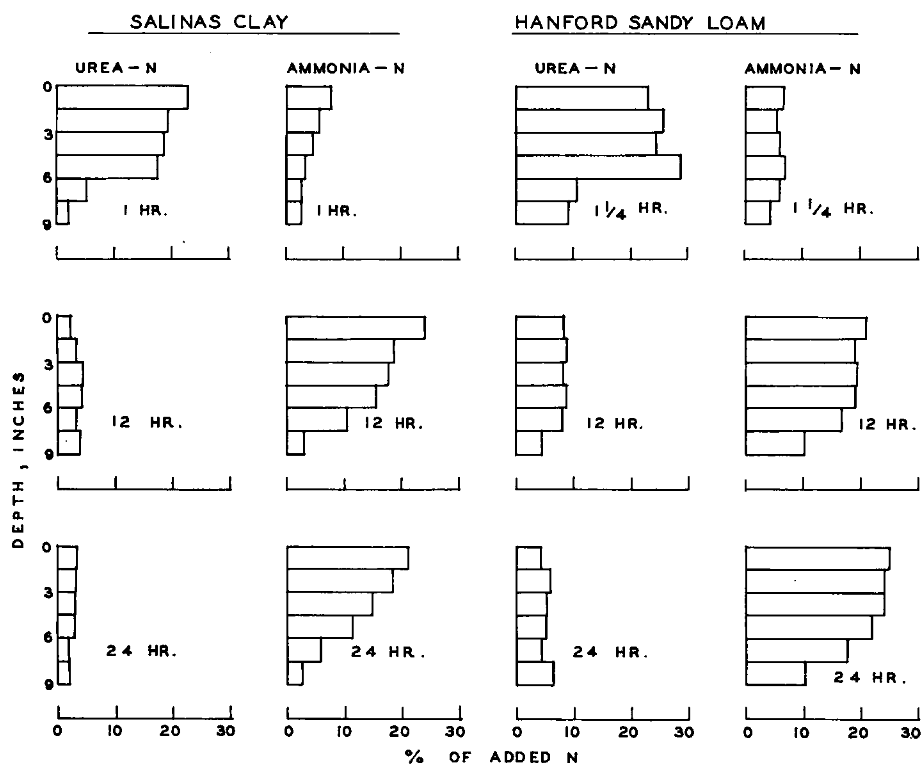
Relative downward movement of three fertilizers in a column of Yolo loam.



Distribution of urea and ammonia nitrogen in columns of two soils after application of urea in solution.



Nitrification of Fertilizers

Results of experiments with three ammonium fertilizers—aqua ammonia, ammonium sulfate, and ammonium nitrate—have shown that not only the rate of nitrification but also the elapsed time before the maximum rate is attained depends on ammonia level in the soil.

When ammoniacal fertilizers are applied to soils, the ammonium ion is usually retained on the soil colloids in a zone close to the point of initial contact. Therefore, band application results in very high localized concentrations of ammonia in soil. The zone in the immediate vicinity of a fertilizer band provides the environment in which the nitrifying bacteria must function. These bacteria obtain their energy from the conversion of ammonia to nitrate, and are active only where ammonia is present. The soil may also have a very high pH—relative acidity-alkalinity—where anhydrous ammonia or aqua ammonia is applied, because these materials make the soil temporarily more alkaline.

The above two paragraphs are published here as they should have appeared in the article on ammoniacal fertilizers on page 9 of the October 1958 issue of California Agriculture *and written by the authors of the accompanying article on the movement of urea in soils. An error made the last sentence in the above paragraph self-contradictory as it appeared in the October article.*

UREA

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column the urea had penetrated, and how much had been converted to ammonium carbonate. In the first series, the columns were sectioned after all the urea had passed into the column, even though the wetting front had not quite reached the bottom. In the second series, the sections were analyzed 12 hours after the urea solution was added and in the third series the time interval was 24 hours.

In Salinas clay both the urea and ammonia showed a concentration gradient after one hour, indicating that part of the urea was retained in the upper part of the column, and that some of the urea had been hydrolyzed to ammonia even in that short interval. After 12 hours hydrolysis was essentially complete. Although the soil was uniformly wetted throughout the length of the column the distribution of added nitrogen decreased markedly with depth.

In Hanford sandy loam, urea distribution at the end of one and one quarter hours was quite uniform down to 6″ and was reflected in the uniformity of the ammonia distribution after 24 hours when most of the urea had been hydrolyzed.

A comparison of the movement of urea, ammonium sulfate, and calcium nitrate applied at the surface of Yolo loam showed that nitrate moves along with the wetting front and is concentrated at the bottom of the column, whereas urea moves downward less readily, and ammonium sulfate hardly moves downward at all.

In experiments where both urea and nitrate were applied to the top of a soil column at the same time, and then water added to move the fertilizers downward, it was found that nitrate was first to appear at the bottom of the column. For example, all added nitrate was leached from a 9″ column of Salinas clay by application of 5.7″ of water, whereas 7.1″ were required to accomplish the complete removal of an equivalent amount of urea.

These experiments indicate that urea is retained by weak absorption forces in the soil, and that until hydrolysis occurs urea is intermediate between nitrate and ammonia in its susceptibility to leaching.

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OLIVE

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gen would soon disappear. Under such conditions, a pronounced response of olive trees to nitrogen fertilizers—as found in these experiments—would not be expected. This would be the case, not only in the initial fertilizer applications, but year after year, as added fertilizers would tend to be lost by leaching and the low level of organic matter in the soil would not be conducive to a natural build-up of soil nitrogen.

In the heavier clay soils on flat ground—as in the Tehama County orchard—nitrogen would tend to be more stable because of the higher organic content and the reduced amount of leaching. Even with no added soil nitrogen, the nitrogen level in the trees would tend to stay for some years well within the range adequate for the needs of the tree; hence, the lack of an immediate response to a single nitrogen application, or to the withholding of a single nitrogen application, is not surprising. Under fertile soil conditions, and where a consistent annual fertilization program is carried on, it is unlikely that any one application of nitrogen could be expected to cause a marked stimulation in the immediate crop.

Maintaining olive trees at the optimum nitrogen level under the soil conditions found in the Tulare and Tehama olive districts would be relatively simple. Because soil nitrogen does not fluctuate appreciably and trees at adequate nitrogen levels do not respond immediately to a single nitrogen fertilizer application, the only problem is that of adding nitrogen to the soil at intervals to maintain the trees at an optimum nitrogen level. The frequency of these intervals can be determined best by leaf analysis, but the appearance of the trees gives a fair indication of their nitrogen status. Dark green foliage together with vigorous annual shoot growth implies ample nitrogen. Further addition of nitrogen fertilizers to trees in this condition or with a leaf nitrogen content of 1.8% to 2.0% is probably not justified because the trees are unlikely to absorb nitrogen much in excess of those values. Even at such high nitrogen levels, however, trees will gradually decrease in nitrogen content after several years and should receive added nitrogen before the leaf nitrogen content drops below 1.2% to 1.3%.

Maintaining olive trees at the proper nitrogen level under conditions such as those found in the Butte County olive district would be much more difficult and is likely to be a major problem of the olive grower. Shallow, gravelly soil with low organic matter and fertility, coupled with heavy leaching due to the rolling topography and high rainfall causes a rapid loss of soil nitrogen, necessitating frequent additions of fertilizer. For trees grown under such conditions, which tend to be continually low in nitrogen, adding the proper amount of nitrogen at the proper time is of definite importance in influencing fruit set and the consequent fruit size.

The problem of nitrogen fertilization encountered in orchards of low soil fertility is twofold. Nitrogen must be added frequently to maintain adequate conditions for growth and to induce adequate fruit setting. However, large amounts of nitrogen should not be applied, especially in the spring just preceding the fruit setting period, as excessive fruit set and, consequently, unprofitably small fruit sizes may result.

In orchards tending toward alternating bearing, heavy nitrogen fertilization in the spring of the on-year would tend to promote the development of a heavy crop, followed by the lack of a crop in the off-year. In such situations a better practice may be to delay the nitrogen application in the on-year until summer—after the fruit setting period—and to apply the nitrogen in the off-year in the spring, preceding the fruit setting period, to stimulate fruit setting.

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PRODUCTION

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Kern, were the other leading counties in 1941. Then, Imperial was the major vegetable producing county.

Though the total value of the Los Angeles County farm output is now nearly twice as much as in 1941, its share in southern California agriculture has declined to 13%. Among the 12 southern counties, Los Angeles now ranks seventh in fruit and nut crops, and fifth in vegetables and in field crops. However, the value of the county's livestock output—especially dairy products—continued to expand, until recently. And, while it has lost ground as compared with other counties—its share in this group having fallen below one fourth of the total—Los Angeles remains the leading livestock county.

Tulare County was the second largest agricultural producer among the southern counties in 1941, although the value of its output was little more than half

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