

Coated Fertilizer for the Controlled Release of Nutrient

BY KIOSHI KURIHARA

Chief, Laboratory of Fertilizer Improvement, Division of Fertilizers, Department of Soils and Fertilizers, National Institute of Agricultural Sciences

Agronomists, farmers and fertilizer technologists have long desired a fertilizer that releases plant nutrients at such a rate as nitrogen release of manure and organic fertilizers. Within the last decade, a major interest of the fertilizer technologists and researchers in Japan has focussed on the development of controlled release fertilizers and nitrification inhibitors.

As a result, considerable progress has already been made. The concept of controlled release or slowly available fertilizer seems to be firmly planted in the thinkings of agronomists and farmers in Japan.

There are two main approaches to achieving controlled release of nutrients. A way is to alter the chemical characteristics of materials: a) development of compounds with limited water solubility, whose nutrients are released in plant available forms directly (metal ammonium phosphate), and only after chemical and microbial decomposition in soil (crotonylidene diurea or CDU, isobutylidene diurea or IBDU and ureaform; b) development of soluble or relatively soluble materials whose nutrients are gradually released only after decomposition by soil microbes (guanylurea salts). These materials are called a slow-release or slowly available nitrogen fertilizer, and used to a relatively large extent for the production of specialized crops in Japan.

Another way of approach is through coating of soluble materials or mixing them with sparingly soluble or insoluble compounds as a matrix, that will delay the rate of release

by a physical barrier. Recently, there has been a surge of research activity on these coated fertilizers in Japan. More than ten fertilizer companies have researched to develop the coating techniques for soluble fertilizers.

As a result, compound fertilizer coated with phenol-formaldehyde resin is now commercially available. In the United States, resin- and sulfur-coated ureas also currently are the slow-release nitrogen products of this type tested most intensively.

Advantages and disadvantages of coated fertilizer

There are several advantages offered by coated fertilizers due to the slow-release of nutrients. From the viewpoint of improving nutrient recovery by crops, main advantages are: a) reduction of nutrient loss via leaching and run-off, and for nitrogen, ammonia volatilization and denitrification; b) reduction of luxury or excess absorption of nutrients by crops during first flush of growth; and c) elimination of seedling damage from high local concentration of soluble fertilizer constituents; d) reduction of nutrient immobilization by the chemical and biological reactions in soil.

In addition, improvement of nutrient recovery through slow-release may result in lowering labor costs due to fewer applications. When compared to altering the chemical and physical characteristics of the fertilizer, coating for slow-release has the following ad-

vantages; i.e. a) easier availability of soluble materials for coating, and b) possibility of various nutrient combinations, including micronutrients.

The major disadvantages of coated fertilizers appear to be in the production. Coating uniformity around every fertilizer is now difficult to obtain with an industrial scale. In addition, coating adds to the cost of the fertilizer because of the additional equipment required in the coating process and in the coating material itself.

The price of coated fertilizers currently investigated appears to reflect from 10 to 50% addition by the coating to the basic price of uncoated materials.

Factors affecting release rate of nutrients from coated fertilizers

Because research on new coating for fertilizers has only recently been conducted on an intensive basis, published reports on progress are somewhat limited, but the main factors affecting the release rate have been revealed.

The release rate is markedly decreased by increase in the coating thickness or times and slightly in the granule size, but increased with increase in the solubility of materials for coating.

As for environmental factors, temperature affects the release rate. For example, increase in temperature from 10° to 20°C almost doubled the initial rate of nitrogen release.

Soil pH, texture, and soil moisture in the range required for normal crop growth are independent on the release rate. But the release rate is rapid in water and in water-logged soil as compared with that in the soil with upland soil moisture.

The presence of biological activity affects the release rate in the fertilizer coated with bio-degraded materials. Generally, coating appears to be more stable in water-logged than aerated soil systems.

Evaluation of slow-availability of coated fertilizers

Several methods have been tried in order to predict the release rate from coated fertilizers in soil systems. However, one of the most popular and useful methods for the laboratory evaluation of slow availability as for coated fertilizers is the determination of release or dissolution rate in quiescent water at a constant temperature (for example, 5-gram sample in 100 ml of water at 25~30°C). Results from this method usually correlated well with the release rate in soil and thus crop response.

A typical nutrient release from coated fertilizer in water generally shows the curve as seen in Fig. 1. The one-day dissolution

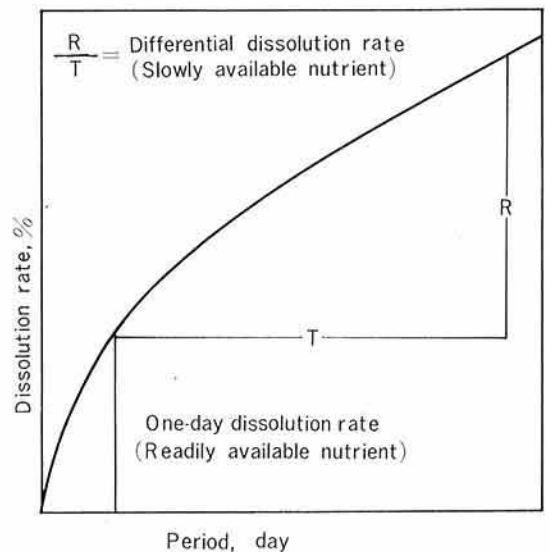


Fig. 1. A typical pattern of dissolution rate from coated fertilizer in water.

rate is taken to indicate the proportion of granules with imperfect coating. Therefore, this dissolved nutrient may be acceptable for a readily available one. After the first day, release of nutrient is fairly linear with time for a certain period and then declines. The average of dissolution rate (per day) during the period of linear dissolution may be taken

to be an indication of slow availability of coated fertilizers.

The relationship between dissolution rate and rice yield obtained by the authors is shown in Fig. 2.

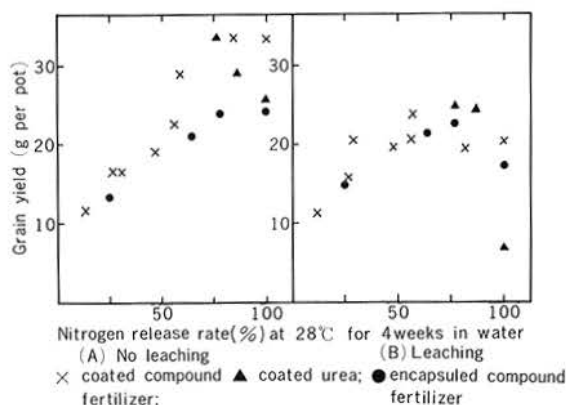


Fig. 2. Relationship between dissolution rate and grain yield of paddy rice in greenhouse experiments.

Crop response to coated fertilizers

Several field tests on paddy rice transplanted to submerged soil were conducted with eight samples of coated fertilizers in 1968 and with eighteen samples in 1969. Typical data are shown in Fig. 3. The obtained results lead us to the following conclusion. The rice growth and yield generally correlated well with the dissolution rate of nitrogen from the coated fertilizers in quiescent water regardless of coating materials.

1) Samples having dissolution rate of more than 90% at 28°C for two weeks in water

In the early season rice growth from a basal dressing of coated fertilizers was consistently more vigorous than from equivalent amounts of ordinary high-analysis compound fertilizer (13-13-13). Increase in tillers was especially remarkable. This confirms that the dissolution rate of this order showed to prevent the leaching and denitrification loss of nitrogen to a great extent.

The nitrogen status of the rice plants was almost the same as that obtained with higher application of nitrogen. Thus, expected grain yield was not obtained, resulting from less spikelets per panicle and less filled grain, in spite of higher panicle and straw yield.

2) Samples with dissolution rate ranging from 60 to 90%

The samples of this group could supply the more adequate amount of nitrogen for optimal growth of rice. The grain yield was higher than from a basal dressing of uncoated fertilizer, and at least equal to and in some locations higher than that obtained with the most suitable multi-application of nitrogen. The rate of growth was slightly depressed early in the growing season, but increased later as compared with uncoated fertilizer.

3) Samples having dissolution rate of less than 60%

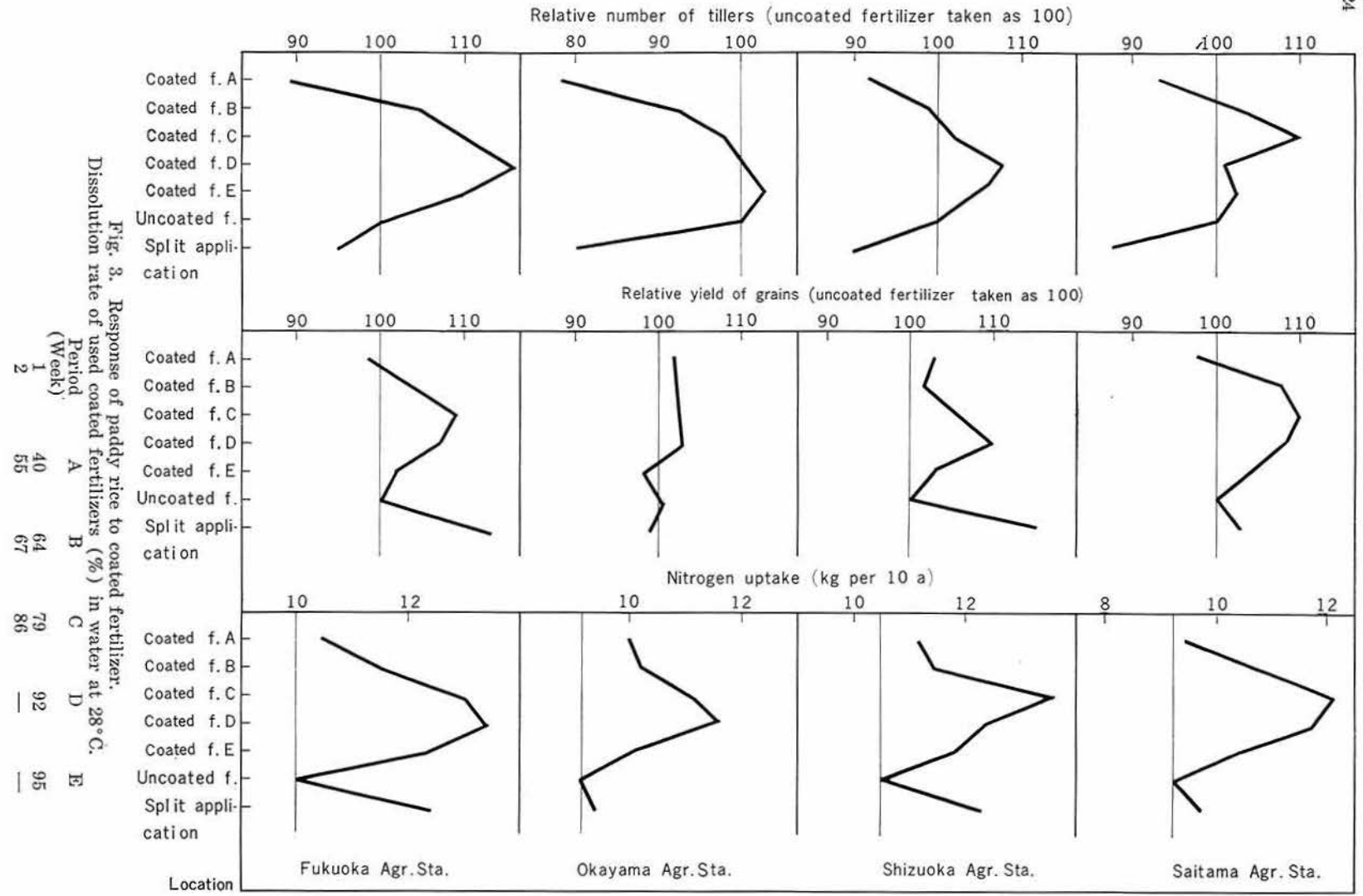
Samples of this group showed too slow-release characteristics by depressing the early growth. Thus, the grain yield resulted in the same as or less than that with uncoated fertilizer mainly due to the decrease in panicle.

Several studies have also been reported for the use of coated fertilizers in the production of upland crops. Field tests have shown coated compound fertilizers having suitable release rate (40 to 80% for two weeks in water) to be promising sources of nutrient, especially nitrogen for vegetables such as tomato, eggplant and strawberry grown in both field and commercial greenhouse.

When applied with phosphate fertilizer in addition to coated compound fertilizer, one application as a basal dressing produced yield of winter oat and irrigated paddy rice comparable or superior to the standard multiple application of conventional fertilizers.

However, contradictory results have also been reported. Coated fertilizers with the same dissolution rate were less efficient for increasing the yield of upland rice and winter onion than uncoated ones.

These different responses to coated fer-



tilizers are largely dependent upon the application rate of phosphate. In the former two field tests phosphate was applied at a rate of 200 to 300 kg per hectare, but less than 100 kg in the latter. Therefore, the lower application of phosphate as well as the too slow-release of phosphate fails to meet its requirements at the early stages of crop growth.

From the viewpoint of plant physiology, an ideal slow-release fertilizer should supply nutrients to the soil solution at a rate exactly equal to the demands of the growing plant. Coated fertilizers will not satisfy the requirements for all cropping situations, but coating may be at least a partial answer for approaching this ultimate goal, especially improving efficiency of nitrogen recovery.

References

- 1) Kurihara, K., Tanaka, T. and Murai, H.: Slow-release fertilizers by coatings. I. Rate of release from capsuled fertilizers, Ann. Rep. Div. Fert., Nalt. Inst. Agr. Sci., 29-32 (1966).
- 2) Kurihara, K. and Tanaka, T.: Slow-release fertilizers by coatings. II. Preparation of coated fertilizers and response to rice, *ibid*, 33-37 (1966).
- 3) Kurihara, K. and Hosoi, A.: Slow-release fertilizers by coatings. III. Effect of coated fertilizers on reduction of nitrogen loss through leaching and salt damage, *ibid*, in press (1970).
- 4) Kurihara, K. and Hosoi, A.: Slow-release fertilizers by coatings. IV. Response of wheat to coated fertilizers in greenhouse experiments, *ibid*, in press (1970).
- 5) Anonymous: Response of paddy and upland rice to coated fertilizers, (Results of field experiments in 1968 and 1969), Research Association of Coated Fertilizer, Tokyo, Japan (1970). [In Japanese.]
- 6) Anonymous: Response of various upland crops to coated fertilizers, Kanto-Tosan Research Association of CSR Fertilizer, Japan (1970). [In Japanese.]