Effect of Slow Release Fertilizer (Meister) on the Nitrogen Uptake and Yield of the Rice Plant in the Tropics

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Abstract: Field experiments on the response of rice plants to slow release fertilizer (Meister 10, MS10) were conducted from the 1986 wet season (WS) to the 1987 WS at IRRI, with ammonium sulfate (AS) as control. IR64 and IR36892-163-1 were planted under two N levels and three spacings. In all experimental plots regardless of season, the amount of N in the plants increased exponentially at the early growth stage \( y = ab^x \) and linearly at the middle and late growth stages \( y = a + bx \), as previously reported. MS10 lengthened the exponential phase and increased parameter \( b \) during the linear phase. The amount of N in the plants was higher in AS than in MS10 plots up to 5 weeks after transplanting. Comparing narrow and wide spacing, the difference in the amount of N in the plants was greater in the MS10 plots. At flowering and maturity, the amount of N in the plants was higher in the MS10 plots due to the higher percentage recovery of basal N and the higher rate of N absorption during the linear phase. The amount of N in the plants grown under MS10 was almost equivalent to those in the plants grown under a double dose of basal AS.

Tiller yielding pattern and achievement of the maximum tiller number stage varied with spacing and fertilizer types, as reflected in the N absorption pattern of the plants. Yield, sink size and potential sink size of the plants reflected the N absorption pattern and the amount of N in the plants. The yield of 6g N - MS10 was almost equivalent to the yield of 12g N - AS. The yield of MS10 plots was especially higher, with narrow spacing due to N absorption during the early growth stage.

Key words: Growth, N-uptake, Rice plant, Slow release fertilizer, Tropics, Yield.

To achieve high yields, plants must absorb a large amount of nitrogen (N). However, imbalance of yield components is sometimes induced in the case of plants holding a large amount of N. It is therefore necessary for plants to have suitable N absorption patterns and well-balanced yield components.

Recently, it was reported that the N absorp-

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Soil fertility, however, is very difficult to improve; topdressing sometimes induces imbalance in yield components and decreases yield\(^5\,\,\,13\) and deep placement requires much labor. Recently, thermoplastic resin-coated urea has been developed as a slow release fertilizer in response to need for a fertilizer which can be applied in a single basal application with a controlled release rate compatible with a specific crop growth duration. Although its use and effect on grain yield are already distinguished and utilized in the temperate areas\(^1,\,\,\,4,\,\,\,5,\,\,\,6,\,\,\,8,\,\,\,9,\,\,\,11\), research work on the effect of this fertilizer on growth and yield of rice in the tropics is limited. Hence, the effect of slow release fertilizer on the N absorption pattern and yield of rice in the tropics are elucidated in this study.

Materials and Method

Field experiments were conducted from the 1986 wet season (WS) to the 1987 WS at the International Rice Research Institute (IRRI) paddy field (Maahas clay soil, Andaqueptic Haplaquoll). Short-duration variety IR64 (110—115 days) and medium-duration line IR36892-163-1-2-2-1 (130 days) were used. Germinated seeds were sown in seedling trays (2 seeds/cm\(^2\)) and transplanted 14 days after seeding under two N levels (6 and 12 g·m\(^{-2}\)) and three plant densities (20×10, 20×20, and 20×30cm). All N fertilizers were applied basally. Meister 10 (MS10) was used as a thermoplastic resin-coated urea fertilizer and ammonium sulfate (AS) as control. Fertilizers labelled with \(^{15}\)N were also applied to the subplots (60×20cm). According to the manufacturer, it takes 100 days for 80% N to be released from MS10 at 25°C under flooded conditions. The nitrogen releasing pattern of MS10 in the IRRI field is shown in Table 1.

A weeny tiller count was carried out to estimate the maximum tiller number stage. Plant samples were collected from the field at weekly intervals from two weeks after transplanting (WAT) until maturity. Plant materials were dried in an oven at 80°C for 48 hours and total N was determined using the Kjeldahl method. The ratio of \(^{15}\)N to total N in the plant was determined using a Mass spectrometer. Yield and yield components were also calculated. Sink and potential sink size were determined using the same methods described in a previous report\(^{12}\); sink size = grain yield \div\% percentage of ripened grains Potential sink size = sink size \div(1-% percentage of degenerated spikelets).

Results and Discussion

\(N\) absorption and growth of plant

Nitrogen absorption patterns in DS are shown in Fig. 1 (N absorption pattern in WS was reported earlier). In both DS and WS, the N absorption pattern was presented as a function of the number of days after transplanting for both AS and MS10 through an exponential equation \((y = ab^x)\) for the early growth stage and a linear equation \((y = a + bx)\) for the middle and late growth stages. No varietal difference was observed in the N absorption pattern between short- and medium-growth duration varieties and no big seasonal difference in the N absorption pattern between DS and WS. However, the duration of the exponential phase was observed slightly longer in DS than in WS because the higher temperature of WS during tillering stage was the same as in a previous report\(^{10}\).

MS10 lengthened the exponential phase while AS increased N absorption at the exponential phase. During the linear phase, MS10 increased the rate of N absorption (parameter 'b'). However, the rate of basal N application and plant spacing did not affect parameter 'b'. During the linear phase, a significant difference in the parameter 'b' of fertilizer types was observed. It was bigger in MS10 than in AS. This may be attributed to the N release pattern of MS10, where 36.8%
of N in MS10 was released at 5 WAT up to the flowering stage of IR64 in 1988 WS. This amount of N is equivalent to 2.2 g m\(^{-2}\).

Total N in the plants grown in 12 g N-AS plot was higher than that in the plants grown in 6 g N-AS and 6 g N-MS10 plots throughout the entire growth stage regardless of spacing and variety (Fig. 2). Under the same N rate (6 g m\(^{-2}\)), the amount of N in the plants at 3 WAT were greater in the AS than in the MS10 plots, even at narrow spacing in both of varieties. At 3 WAT, the difference in the rate of N absorption among spacings became apparent, especially in the MS10 plots in both varieties. Up to 5 WAT, narrow spacing promoted N absorption by the plants, especially in the MS10 plots, and the difference in the amount of N in the plants among various spacing became more apparent (Fig. 2). From 5 WAT to flowering stage (67—71 DAT IR64; 86—88 DAT IR36892-163-1-2-2-1), significant differences in N uptake were noted among spacings and between fertilizer types in both varieties. A larger amount of N was absorbed at wide spacing than at narrow spacing due to the difference in the duration of the exponential phase. Similarly, a large amount of N was absorbed in the MS10 than in the AS plots because of the higher N absorption rate in MS10 plots.

The percentage recovery of basal N at different growth stages reflected the N absorption pattern. Higher percentage recoveries of basal AS and MS10 were noted in narrow spacing at both sampling times (Table 2). At 5 WAT, percentage recoveries of basal N from AS plots were 27.3% in 20×10 cm spacing and 21.2% in 20×20 spacing, while values from MS10 plot were found to be 25.3% and 18.2%, respectively, and slightly lower under each spacing. In MS10 plots at flowering stage, percentage basal N recoveries for both spacing were 42.7% and 37.7%, respectively.

### Table 2. Amount of N in plants at different growth stages (g/m\(^2\)).

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Fertilizer</th>
<th>5 WAT</th>
<th>Flowering</th>
<th>5 WAT</th>
<th>Flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Soil</td>
<td>Fertilizer</td>
<td>Recovery (%)</td>
</tr>
<tr>
<td>20×10</td>
<td>(NH(_4))(_2)SO(_4)</td>
<td>4.43</td>
<td>2.79</td>
<td>1.64</td>
<td>27.3</td>
</tr>
<tr>
<td></td>
<td>MS10</td>
<td>4.51</td>
<td>2.99</td>
<td>1.52</td>
<td>25.3</td>
</tr>
<tr>
<td>20×20</td>
<td>(NH(_4))(_2)SO(_4)</td>
<td>2.82</td>
<td>1.55</td>
<td>1.27</td>
<td>21.2</td>
</tr>
<tr>
<td></td>
<td>MS10</td>
<td>2.34</td>
<td>1.25</td>
<td>1.09</td>
<td>18.2</td>
</tr>
</tbody>
</table>

Variety Used: IR64, 1987 WS.
while those in the AS plot did not vary much from 5 WAT. This suggests that the absorption of basal N is almost complete at 5 WAT in the AS plots but the process continued up to the flowering stage in the MS10 plots. Although plants grown in MS10 and AS plots differed in fertilizer absorption patterns and percentage recoveries of basal N, the difference in the amount of absorbed soil N between fertilizer types was statistically not significant. After flowering, the amount of N absorbed by the plants was higher in the MS10 plot than in the AS, regardless of spacing.

The amount of N absorbed from 5 WAT to maturity did not differ much between the 6g N–AS and 12g N–AS plots. At flowering and maturity, therefore, the amount of N in the plants grown under MS10 was very close to that in the plants grown under a double dose of basal N (12g N–AS). This was attributed to the higher percentage recoveries of basal N in MS10 plots.

There was a difference in the tillering pattern and occurrence of the maximum tiller number stage between fertilizer types in both DS and WS, reflecting the N absorption pattern of the plants. Decrease in the tiller number after the maximum tiller number stage was less in MS10 plots than in AS plots in both DS and WS. The maximum tiller number stage in AS plots occurred a week earlier than in MS10 plots regardless of spacing (Fig. 3). However, the difference in the time of occurrence of the maximum tiller number stage between fertilizer types was observed to be smaller in narrow spacing during DS compared with WS. Also, the difference in the time of occurrence of the maximum tiller number stage between fertilizer types was observed to be smaller in the temperate area than in the tropics by preliminary experiment. At present, this relationship is not yet fully established and further investigation is necessary. On the other hand, the effect of fertilizer types on the times of panicle primordia initiation and flowering was not readily apparent—2–4 days later in MS10 than in AS plots—regardless of crop season and plant densities.

**yield and yield Components**

The relationship between sink or potential sink size and the amount of N in the plants at the late stage of spikelet initiation of the 1987 DS is shown in Fig. 4. There was a close relationship between sink or potential sink size and the amount of N in the plant. Sink–N relationship in WS was observed as same as in DS. This strongly suggests that potential

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**Fig. 3.** Pattern of tillering of rice plants grown under different types of nitrogen fertilizer (1987 DS).

**Fig. 4.** Relationship between sink size and amount of nitrogen in plants at the late stage of spikelet initiation.
sink size and sink size were mostly affected by the amount of N at the late stage of spikelet initiation. A negligible effect of the type of fertilizers on the contribution of N to potential sink size and sink size was observed. However, varietal differences in the contribution of N to sink size or potential sink size were apparent. Under the same N level, IR36892-163-1-2-2-1 had a slightly higher contribution of N to potential sink size at the late stage of spikelet initiation and flowering than did IR64. This was due to the longer duration of the vegetative lag phase\(^9\). On the other hand, there was no difference in sink size between IR64 and HR36892-163-1-2-2-1 because there were more degenerated spikelets in the latter.

Yield and yield components in the 1987 DS are shown in Fig. 5. The same trends in yield and yield components were observed in the 1986 WS and 1987 WS. There were no significant differences in grain yield, sink size and potential sink size between 6 gN-MS10 and 12 gN-AS, reflecting the N absorption pattern in both IR64 and IR36892-163-1-2-2-1. Under the same N level of basal N(6 g·m\(^{-2}\)), there were big differences in grain yield, sink and potential sink size, and higher values were obtained from MS10 plots. Percentage of degenerated sink size was almost equal in all plots within an identical variety in spite of big differences in potential sink size and N absorption during reproductive stage. This suggests that the increase in N absorption during the linear phase has no apparent effect on sink degeneration in the tropics. Therefore, the contribution of N in the plants at flowering to sink size became lower in MS10 than AS plots. Also, the percentage of ripened grains was almost equal in all the plots within an identical variety in spite of big differences in sink size and N absorption during ripening period. It was noted that the yields of MS10 plots were particularly higher in narrow spacing than in wide spacing treatments. This can be explained by N absorption pattern. Among plant spacings, the difference in the amount of N in the plant was larger in MS10 plots than in AS plots.

From these results, enhanced yield by MS10 application could be attributed to an increase in sink size which increased with N absorption and not to improved ripening decreased sink degeneration. This is supported by previous reports which indicated that the yield is mostly affected by sink size in the tropics\(^12,15,16\). In the temperate area, it is also reported that MS10 improved N nutrition of plant at the middle and late growth stages and increased yield through increasing sink size. However, research work on the contribution of MS to the yield determining process of plants grown in the temperate area is limited. The effect of MS on the yield might vary with climate and soil. Further studies on the effect of MS on the yield determining process of plants grown under different climates and different soils is required.

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