EFFICIENT FERTILIZER MANAGEMENT PRACTICES
FOR HIGH YIELD RICE PRODUCTION OF
GRANARY AREAS IN MALAYSIA

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ABSTRACT

High yield targets in modern rice farming should be supported by effective and efficient fertilizer management practices. Overdependence on blanket subsidy fertilizer recommendation is unable to produce high yield. Site-specific balanced fertilizer recommendation option by FERTO package is able to enhance crop performance, subsequently achieving high yield target. The significant yield increment (up to 300 %) using FERTO package recommendation is accomplished because due consideration is given to four basic principles of fertilizer management, i.e. nutrient quantity, nutrient access, indigenous soil fertility status, and balanced crop requirement. Site-specific approach of the FERTO package recommendation is complex. Therefore, FERTO package recommendation is more applicable to large-scale commercialized rice production. Thus, for policy formulation, FERTO package recommendation has to be transformed into formulation according to cropping zones. Development of fertilizer formulation according to cropping zone is more practical and can easily be managed by fertilizer suppliers and rice estate managers. The formulation can also be adapted by progressive small-scale farmers. Fourteen fertilizer formulations for specific management zones within the granary areas were identified in this study. The formulation is able to enrich proportionate vegetative and reproductive growth for high rice-yield performance. However, the application of FERTO package recommendation rate can be further enhanced by using straight fertilizers in place of the present subsidy mixture or compound fertilizers. These straight fertilizers are much cheaper compared to the mixture or compound fertilizers in the market. Therefore, the adoptions of FERTO package using straight fertilizers will reduce cost of production and ultimately increase net farm returns.

Keywords: Rice, FERTO package, fertilizer recommendation, high yield, granary areas.

INTRODUCTION

Overdependence on fertilizer input to boost yield performance is a common practice in rice farming. Subsidy fertilizer was introduced in Peninsular Malaysia in 1979 (Wong and Jegatheesan, 1990). The subsidy fertilizer is a blanket recommendation rate. The recommendation was developed through fertilizer studies under transplanting cultural practices using varieties with low to medium yield performance (3.5-5.0 t/ha). As a result of rapid industrialization and rising labor costs in the late 80s, the labor-intensive transplanting technique was abandon and farmers opted for direct seeding (Hamzah and Zanil Abidin, 1990). Since then, production system in rice farming (post-harvest field management, land preparation, crop establishment, weed management, pest and disease control, and new high-yielding variety) has greatly improved. The amount of nitrogen (N) in the subsidy fertilizer was also increased from around 63 kg/ha in early 1980s to 80 kg/ha in late 1980s, and further increased to 110 kg/ha in 1990s (Aminuddin et al., 2004). The blanket approach of fertilizer recommendation remains until now. However, the national and granary average yields only hover around 3.5 and 3.8 t/ha, respectively (Abd Razak et al., 2004).

The National Agricultural Policy 3 (NAP3) placed significant importance on food security, improving farm return, and eradication of poverty among farmers (Anon, 1999a). Rice farming, dominated by poor farmers, is one of a targeted sector that was given the emphasis. Towards this, the Ministry of Agriculture (MOA) proposed a new yield target of 10 t/ha (Abd Razak et al., 2002), which subsequently would increase farmer’s income. With the introduction of modern high-
yielding varieties as a result of intensive research and development program, the targeted yield will reasonably be achievable. However, the newly introduced variety is known to be more responsive to fertilizer (Kundu and Ladha, 1999). Experiences have shown that the blanket fertilizer recommendation, which lack consideration for balanced crop nutrient requirement and in-situ soil fertility status, is a major factor constraining high yield achievement of the new varieties. Therefore, this paper examines a new approach of fertilizer management technology towards approaching 10.0 t/ha yield target under a set crop for high production. It involves FERTO package application to calculate site-specific balanced fertilizer recommendation for set high-yield target.

MATERIALS AND METHODS

FERTO package verification

The Fertilizer Recommendation Tool (FERTO) package was developed by MARDI. It provides site-specific fertilizer recommendation options. Before embarking on the exercise, the fitness of the model needs to be verified. For that purpose, various production-scale trials during main and off-seasons were conducted in MADA Kedah and KADA Kelantan. Soils from the study plots were sampled before land preparation. The soil was analyzed in the laboratory to determine its physico-chemical characteristics. Data was used to run the model, after which fertilizer recommendation for high yield production of the sites were produced for validation.

Farm management activities started immediately after previous crop harvesting. The first activity was post-harvest field management involving slashing and burning of the above ground biomass. It was followed by first and second rotovations with raking under dried field condition. Final rotovation with land smoothing (nuplo) was carried out under wet condition. Immediately after that, broadcast seeding under water using motorized blower was undertaken. Germinated seed at rate 150 kg/ha of variety MR219 was used in this study. After seeding, in-field water was drained to saturation point for even seedling establishment. Other routine agronomic practices throughout the cropping cycle were strictly followed, such as infield water-depth control, weed management, and pest and disease control to ensure a better crop growth and to minimize yield loss. Fertilizer rate with four split applications, as recommended by FERTO package model, was followed. Various growth performance indicators of crop at vegetative and reproductive stages such as number of tiller per square meter, number of leaf per tiller, and crop height were monitored to ensure crop achieve criteria of high production performance crop set. Finally, overall plot yield was measured during harvesting. Crop data will be used to indicate the performance of FERTO package recommendation in achieving high yield target. Yield from the study plot will also be compared with yield from the neighboring plots that were managed by farmer.

Mapping of fertilizer recommendation for granary areas

In Peninsular, rice is planted on 44 major soil series covering eight granary areas (Table 1). The physico-chemical characteristics of the soils were extracted from various soil survey reports prepared by Department of Agriculture. The data was used as input databases together with pre-set nutrient status for high-yielding crop and the set yield target to run the model. Only output from fertilizer recommendation window of the model that consists of N, P2O5, K2O, and processed chicken manure (CM) was used to develop fertilizer recommendation maps through integration with geographic information system (GIS). Each recommendation rate was spatially displayed by one pixel that represents the actual area sizes of 100 ha.

Development of fertilizer management zone

Using cluster analysis of GIS, fertilizer recommendation rates were summarized into fertilizer management zones. Dominant fertilizer recommendation rate of a growing area was used to represent the fertilizer management zones. Range of maximum and minimum fertilizer rate of each fertilizer element was also taken consideration.

RESULTS AND DISCUSSION

Fertilizer recommendation rate

Table 2 shows the fertilizer recommendation rates that were generated by FERTO package for plots in MADA and KADA areas, based on the physico-chemical properties of the soils and the set yield target. The recommendations had fertilizer rates...
ranging between 124 and 197 kg/ha for N, 45 and 95 kg/ha for P$_2$O$_5$, 129 and 222 kg/ha for K$_2$O, and between 800 and 3400 kg/ha for chicken manure (CM). Generally, potassium fertilizer and chicken manure are recommended in higher amounts for crop in KADA, than in MADA. It is due to low potassium and cation exchange capacity (CEC) status of KADA soils, thus inability to enhance high yield. Soils originating from riverine alluvium with 1:1 parent material clay like KADA are generally of low inherent fertility status. MADA soil with marine 2:1 clay are always better in fertility status as indicated by their high organic matter content and CEC status. These two parameters are important to ensure that the fertilizer applied can be held by the soil before it can be taken up by the crop. Otherwise, the crop has less opportunity to absorb the applied fertilizer because most of it will be lost through leaching process.

Normally, applied fertilizer is recommended to be split into various applications timing to optimize crop nutrient uptake and minimize loss through leaching and evaporation processes. Therefore, FERTO package recommends four split applications, i.e. basal dressing, first top-dressing, second top-dressing, and final top-dressing during specific crop growing stages (Table 3). For basal application, compound fertilizer (15:15:15) at a blanket rate of 200 kg/ha was applied at seedling stage, about 15 days after seeding (DAS). Split applications of straight fertilizers for top-dressing were varied according to locality, depending on the rates recommended by FERTO package (Abd Razak et al., 2004). Chicken manure, if recommended, will be applied at early tillering stage, about 25 DAS. Fertilizer rate for each split application will be calculated by the model as formulated in the knowledge base. High N and K$_2$O rates were recommended at vegetative and reproductive stages, respectively. This will ensure development of quality tillers and productive panicles to attain high yield performance.
Crop yield performance

The yields obtained from the study plots with FERTO package recommendation rates and from the farmer plots are summarized in Table 4. The yields ranged from 7.1 to 10.1 t/ha with the FERTO package rate and from 1.7 to 5.5 t/ha with farmers’ management. The yield was increased significantly in Senor (KADA) exceeding 300 %, while in Kobah (MADA) yield improvement exceeded 80 %. In Ketereh and Meranti, yield increase between 125 and 200% was recorded. The yields from FERTO package plot were higher compared to the farmer’s plot, indicating that the application of FERTO package rate has positive impact on improving rice yield performance. The success of the recommendation is attributed to the incorporation of four principles of effective fertilizer management to ensure proportionate vegetative growth and reproductive development (Suhaimi and Abd Razak, 2004). These principles are:

i. Nutrient quantity (amount of fertilizer required for set yield target),

ii. Nutrient access (continuous nutrient availability throughout a cropping cycle),

iii. Indigenous soil fertility status, and

iv. Balanced crop nutrient requirement (appropriate nutrient ratio at specific crop stages).

Based on the achievements, the recommended FERTO package rates are able to improve rice yield performance towards achieving the set yield target.

Table 3. Split applications of FERTO package fertilizer recommendation rate.

<table>
<thead>
<tr>
<th>Location: Senor (KADA)</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling date: 15/04/03</td>
<td>149</td>
<td>95</td>
<td>222</td>
<td>2418</td>
</tr>
<tr>
<td>Season: I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeding date: 15/05/03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application</th>
<th>Crop stage</th>
<th>NPK (15:15:15)</th>
<th>UREA (46)</th>
<th>MOP (60)</th>
<th>TSP (46)</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal dressing</td>
<td>Seedling</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic fertilizer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Top-dressing</td>
<td>Early tillering</td>
<td>42</td>
<td>72</td>
<td>110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Top-dressing</td>
<td>Panicle initiation</td>
<td>132</td>
<td>124</td>
<td></td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Final top-dressing</td>
<td>Initial heading</td>
<td>84</td>
<td>124</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Yield performance based on FERTO package and farmer fertilizer rates

<table>
<thead>
<tr>
<th>Granary</th>
<th>Location (Season)</th>
<th>FERTO Plot size (ha)</th>
<th>FERTO yield (t/ha)</th>
<th>Farmer yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MADA</td>
<td>Kobah (1/2000)</td>
<td>3.1</td>
<td>10.1</td>
<td>5.5</td>
</tr>
<tr>
<td>KADA</td>
<td>Ketereh (1/2001)</td>
<td>0.4</td>
<td>8.1</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Meranti (1/2002)</td>
<td>1.2</td>
<td>7.6</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Meranti (2/2002)</td>
<td>1.2</td>
<td>7.9</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Meranti (1/2003)</td>
<td>1.2</td>
<td>8.7</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Senor (1/2003)</td>
<td>1.3</td>
<td>7.1</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Spatial fertilizer recommendation

Fertilizer recommendation rates for high rice yield performance of granary areas are spatially displayed in different N, P2O5, K2O, and CM maps (Fig. 1-4). The recommended rate is based on single pixel that represents 100 ha on the ground. The nitrogen, phosphorus and potassium fertilizer rates range between 109 and 198, 79 and 97, and 135 and 233 kg/ha, respectively. The chicken manure (media with capacity to continuously supply available nutrient in minute quantities throughout the crop cycle) ranges between 0 (no application) and 3.2 t/ha. Soils with CEC exceeding 25 meq/100 g soil do not require chicken manure application due to their ability to hold applied nutrients and are less prone to leaching process. Based on FERTO package yield performance, it can be concluded that the blanket subsidy fertilizer rate (120N: 60P2O5: 40K2O kg/ha) is deficient in nutrients to achieve the yield target. Therefore, to achieve the high yield target set by MOA, additional fertilizer, as recommended by FERTO package, should be included in the recommendation. The additional fertilizer can be incorporated into the present policy of subsidy fertilizer to help poor small-scale farmers realize the high yield target.

Fig. 1. Nitrogen fertilizer rate (kg/ha) for high yield performance of rice in the granary areas
Fertilizer management zone

The use of site-specific FERTO package recommendation as a new subsidy fertilizer is complicated. The recommendation rate may hinder producers or suppliers to formulate the fertilizer. To overcome the problem, re-grouping the recommendation based on dominant recommendation rate through cluster analysis was done. Each recommendation rate is specifically targeted for a cropping zone. A total of 14 cropping zones were identified. Table 5 shows the fertilizer recommendation zones of N, P$_2$O$_5$, K$_2$O and CM that can be utilized to achieve 10 t/ha yield target. The N, P$_2$O$_5$, K$_2$O and CM range between 140 and 170, 80 and 95, 190 and 230, and 800 and 2500 kg/ha, respectively. The FERTO package recommendation zoning essentially is the delineation of the current eight granary areas into 14 zones with location-specific fertilizer rate (Table 5).

On top of efficient fertilizer management, other agronomic practices must come together towards achieving sufficient crop population for set high-yield target. Insufficient crop population per unit area is one of the major constraints that hinder high yield performance. The problem will exist due to existence of low and high spots in the plot due to poor land preparation (Suhaimi and Abd Razak, 2004). Low spot will cause water ponding, subsequently resulting in low seedling establishment. High spot will expose the soil surface to drying, causing tiller death and heavy weed infestations. High spot with shallow water depth will stimulate the crops to produce excess tiller numbers. This phenomenon will result in the development of non-uniform tiller quality that
Fig. 3. Potassium fertilizer rate (kg/ha) for high yield performance of rice in the granary areas

Fig. 4. Chicken manure rate (kg/ha) for high yield performance of rice in the granary areas
definitely cannot produce high yield performance. Proper management of infield water depth together with application of chemicals will prevent weed infestation effectively.

Other yield reduction factors affecting high yield performance are pest and disease attack (Abdul Latif et al., 1990), and harvesting and field handling losses. Pest and disease attack can be minimized through calendar sprays as practiced by many progressive farmers. Harvesting and field handling losses can be reduced through proper supervision during operation by respective growers.

### CONCLUSION

From the present study, it can be concluded that adoption of proposed FERTO package fertilizer management practices is able to achieve the 10 t/ha yield target. The practice will enable rice farmers to achieve high and sustainable rice production at farm level. Subsequently, national rice production can be increased, self-sufficiency level can be met, and import of rice commodity can be reduced for the purpose of balance of trade. The complexity to follow FERTO package recommendation as mentioned earlier can be overcome if growers are willing to accept a new subsidy fertilizer approach using straight fertilizers. Under such circumstances, the FERTO package recommendation can be adopted by growers with additional benefit of cost saving because straight fertilizers are cheaper than the compound fertilizer currently used. This will increase crop performance and yield achievement, reduce cost of production, and increase net farm return.

### REFERENCES


