Evaluation of the Recent Nitrogen Fertilizer Recommendation for Rice Variety Bg 300 in Dry Zone of Sri Lanka through a Modelling Approach

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Abstract

In most regions of Sri Lanka, rice is grown with intensive management under both irrigated and rainfed, low-land puddled conditions. Apart from use of high yielding improved rice varieties recommended by the Department of Agriculture, and timely management of pest and diseases; high rates of nitrogen (N), phosphorus and potassium fertilizers are applied to attain high grain yield. Nitrogen is recommended to be applied in three splits *i.e.* basal dressing at the time of planting and top dressings at tillering and panicle initiation to increase the N-use efficiency. Farmers apply excess amounts of N because of the availability of subsidised N fertilizers. Based on the latest research findings and to improve the efficiency and effectiveness of N application, the Department of Agriculture recently recommended an application of four splits of N without the application of basal dressing. Therefore, in this simulation modelling study yield response of a widely grown Sri Lankan rice variety Bg 300 under two N application recommendations; with and without the addition of basal dressing was analyzed using the simulation model APSIM. Results revealed that yield obtained through the new recommendation was similar to that of the previous recommendation.

Key words: APSIM, Fertilizer, Nitrogen, Rice.

Introduction

Paddy rice (*Oryza sativa* L.) is the staple food for Sri Lankans and is cultivated as a wetland crop in all districts. The total land area devoted for paddy rice cultivation is estimated to be around 708,000 ha (Department of Census and Statistics, 2011). In the major part of the island, rice is cultivated during *Yala* (rain from the first inter-monsoon from March-April and the south-west monsoon from May to August) and *Maha* (rain from the second inter-monsoon from September-October and the north-east monsoon from October-February) seasons.

Inorganic fertilizer prices increase in the world market continuously. Sri Lanka does not own resources with good quality to produce inorganic fertilizers required for the rice crop, and all required fertilizers are imported annually. Amount of urea fertilizer imported to the country is greater than that of other fertilizers. In order to make the rice farming more viable and profitable to farmers, the Sri Lankan government provides urea at a subsidised rate. Therefore, government spending on urea is huge and farmers frequently used to apply over doses.

Sri Lankan government Department of Agriculture has been conducting research on the ways to increase the fertilizer-use efficiency of rice without a significant yield loss and also to reduce the amount of fertilizer import. It is proposed that one way of increasing N-use efficiency is through the cut-down of urea from the basal-dressing while increasing the number of splits as top dressings (Table 1). The objectives of the current fertilizer recommendation were to get the maximum

Table 1. Urea fertilizer recommendation (kg/ha) for Bg300 grown in the dry-zone low country

Time of application (weeks after broadcasting)	Previous recommendation	New recommendation (2013)
Basal dressing	12.5	-
2	87.5	50
4	-	75
6	125	65
7	-	35
Total	225	225

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nutrient-use efficiency, minimize the environment and health hazards, and get the optimum yield under different climatic conditions.

Management of the availability of major nutrients such as N, phosphorus and potassium along with micronutrients is needed for optimum growth and yield of the crop (Dhanapala, 2000). Nitrogen management of rice growing soils in Sri Lanka is the most important factor as the return from rice crop depends on its proper management. Therefore, in this study the yield response of a widely cultivated rice variety Bg 300 in two nitrogen fertilizer recommendation was studied for an area with high yield potential in Sri Lanka.

Materials and Methods

Parameterization of the APSIM Model

The APSIM version 7.3 was used to parameterize the *APSIM-ORYZA* module for Sri Lankan rice varieties. Phenological parameters for Bg 300 was used from published literature (Rathnayake and Malaviarachchi 2011; Suriyagoda and Peiris, 2011). The *oryza.ini* file in APSIM was modified accordingly to simulate the rice productivity at Maha-Illuppallama area (DL_{1b}) in the Dry zone of Sri Lanka. Soil characteristics of the study area (*i.e. Great soil group* Low Humic Gley-LHG, Ketagal Ara series) were extracted from the available literature (Mapa *et al*, 2010). Daily weather data (maximum and minimum temperatures, rainfall and sunshine hours) from January 1976 to December 2011 for Maha-Illuppallama were collected from the Natural Resource Management Center (NRMC) of the Department of Agriculture, Peradeniya.

Model testing

The secondary data on yield were collected from the Field Crops Research and Development Institute (FCRDI) at Maha-Illuppallama. Fertilizer and management practices were identified according to the recommendations of the Government Department of Agriculture of Sri Lanka. Planting dates, planting method (direct seeding), and fertilizer management strategies were adjusted in the model simulations as data collected from the research station. The simulated yields and phenology were used to compare the observed and predicted values once simulated using the appropriate weather data. Crop yields collected from literature were used to validate the model. Simulated and observed data were plotted on a 1:1 graph between predicted and observed values for Bg300. The statistical expressions used for comparing the simulated and field measured data were the coefficient of variance (CV), root mean square error (RMSE) and coefficient of residual mass (CRM) (data not shown).

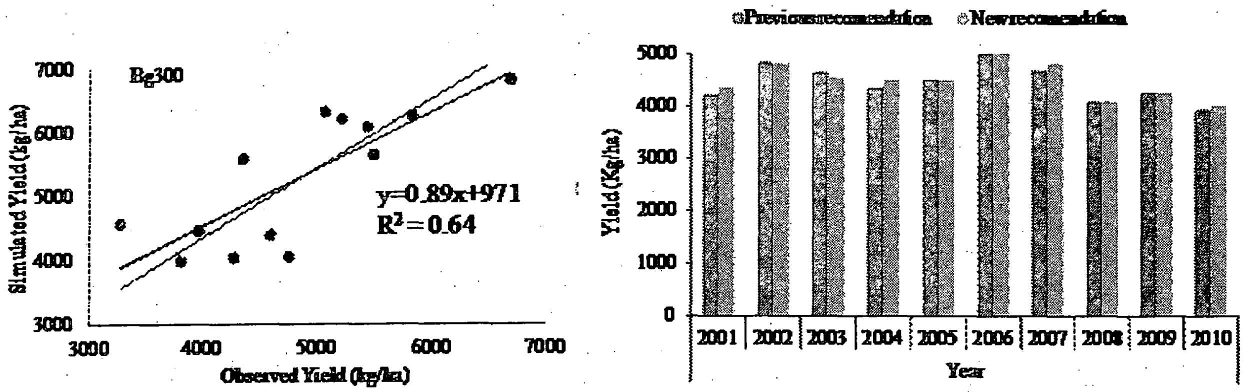
Definition of Scenarios Modelled

Sri Lankan Department of Agriculture has been conducting research trials on the ways to increase the fertilizer-use efficiency of rice without a significant yield loss. Conducting multi-locational field experiments for several seasons and different locations consume much of the resources. In such instances, use of a well parameterised model to test the effectiveness and efficiency of a new management practice will provide added advantages. Therefore, a well parameterised rice model under Sri Lankan context was used in the current simulation to test the efficiency of new recommendation of urea fertilizer application. In this modelling exercise the yield response of Bg300 was simulated for previous and present urea fertiliser recommendations as given in Table 1.

Results and Discussion

The zero origin (1:1) graphs of the relationship between model simulated and field-observed data illustrates that for short term rice variety (Bg 300) APSIM has simulated similar yields for corresponding observed yields with coefficient of determination of R^2= 0.64 (Fig. 1A). The analysis of the past 11 years of yield data with respect to the two fertilizer recommendations revealed that the average grain yield of Bg300 was 4500 kg/ha for both old and newly recommendations (Fig. 1B).

new N fertiliser recommendation for Bg 300 in the dry zone areas is effective as the previous recommendation.



A B

Figure 1. A: Observed and simulated yield of Bg300 rice varieties grown during Yala and Maha seasons at Maha-Illuppallama B: The simulated grain yield of Bg300 during *Maha* seasons under previous and new nitrogen recommendations

Rice cultivation in the dry zone of Sri Lanka show that nitrogen fertiliser applied at a higher rate (12.5 kg N /ha) as the basal application is not efficiently utilized by the rice crop and most of the fertilizer nitrogen applied was wasted. The grain yield of rice is dependent on the total biomass production. Hence, the total biomass production should be increased to increase the grain yield. Maximum biomass production could be obtained only if the N is not limiting at any stage of growth. Furthermore, N uptake by the crop varies with the age of the crop. At the early stages of the crop growth, amount of N taken up by the crop is low. As a result the amount of N available in the soil is adequate to reach the crop demand and application of high rates of additional N as the basal is not required. However, as the rice crop grows the amount of N required by the crop is much higher than its initial growth stages and the provision of adequate amounts as split fertilisers is required to attain a higher growth and yield while maximising the N-use efficiency. Our results from the simulation study reveal that the

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