Mineral nitrogen and rice production in Myanmar

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Abstract
Myanmar, like other countries in Asia, has made great efforts to intensify the production of rice (*Oryza sativa* L.) to feed a rapidly growing population. Most of these efforts concentrated on lowland paddy fields with irrigated double rice cropping systems. Nitrogen (N) rates applied by Myanmar farmers are generally low and do not consider economic aspects. Mineral nutrient management is crucial to boost rice production as N is the most limiting nutrient. There is substantial potential to raise rice production by increased use of N fertiliser, which will increase regional demand for fertilisers and the supply of rice in the international market in the near future. At this pivotal time in Myanmar's development it is timely to elucidate the biophysical and socio-economic factors that lead to financially and environmentally viable intensification of rice production based largely on N fertilisation.

Key words
Mineral nitrogen, fertiliser, sustainability

Myanmar and rice production

Myanmar, formerly Burma, the second largest country of Southeast Asia, is located between 9°58'N to 28°31'N and 92°9'E to 101°10'E. The population of the country was approximating 51.7 million in 2014, and is increasing at an annual rate of 1.01%. At present about 70% of Myanmar's population are rural dwellers whose livelihoods depend on farming. The agricultural sector contributes 22.1% to the GDP, 20% to the total export earnings and it employs 61.2% of the labour force. Rice is by far the most important crop and is grown in areas categorised as rainfed, irrigated and upland, occupying 48%, 20% and 3% of the total sown area, respectively (MoAI, 2014, 2015; NFPWG, 2001).

Before World War II (1921-1941) Myanmar was the largest rice exporting country in the world. After gaining independence considerable attention was given to increasing rice productivity but Myanmar's role in the world rice market declined after the 1960s (Dawe, 2002). From 1977/78 to 1985/86, the Whole Township Paddy Production Program, as a part of the Green Revolution, through the High-Yielding Program was implemented to increase rice production by the introduction of modern rice varieties in combination with improved production technologies. As a result of this program, rice yields increased from 1.8 to 3.1 t ha^{-1} during that period. Despite continuing efforts of the Myanmar government and farmers, the national average yield is still stagnating between 3 to 4 t ha^{-1} (MoAI, 2015).

Mineral nitrogen and rice productivity

Denning et.al (2013), Cho Mar Htwe et.al (2016) and Aung Naing Oo et.al (2016) consistently observed that N was the most limiting nutrient for irrigated lowland rice, followed by phosphorus (P) and potassium (K). Limited use of mineral fertilisers is a major factor limiting rice productivity in Myanmar (Garcia et al., 1999). High yielding rice varieties (HYV) are cultivated extensively but with small rates of N fertiliser the farmers are not achieving crop yield potential. National average rice yields stagnated at 3~4 t ha^{-1} since 1995 mostly due to the low rates of fertiliser applied. Fertiliser rates averaged only 5 to 21 kg NPK ha^{-1} in 1995-2009 (Rice Almanac, 2013). Fertiliser rates in Myanmar are significantly lower than neighbouring countries (Figure1).

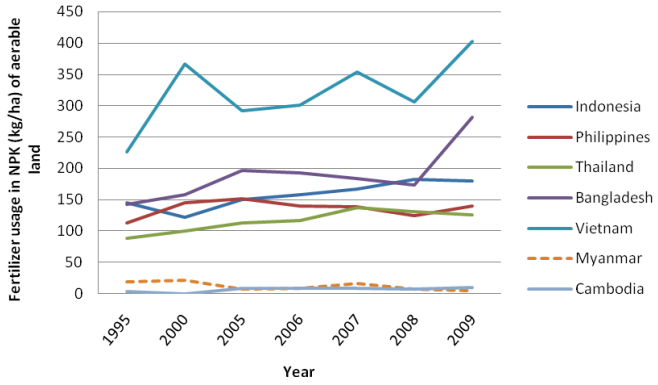

Figure 1. Fertiliser use in NPK (kg ha^{-1}) by neighbouring countries.

Recent research by the International Rice Research Institute (IRRI) in south-east Asia and southern China aimed to improve rice production by farmers and included a focus on optimising N fertiliser in terms of financial returns to farmers and minimising environmental impacts from excessive use and losses to surface and groundwater, and to the atmosphere. Solutions include reducing the rates of N fertiliser currently being used by some farmers (IRRI, 2016). Recommendations for rice production in nearby countries (Thailand, Vietnam, Indonesia, and southern China) include reductions in the use of N fertiliser, whereas in Myanmar there is need to take a sustainable intensification approach including increasing the use of fertilisers, particularly N.

Mineral nitrogen, food security and nutrition

Nitrogen is involved in all plant metabolic processes and is the major component of plant proteins, which tend to accumulate in rice grain. N fertiliser applications normally increase grain yield or protein content, or both (Eppendorfer 1975). This is particularly important in Myanmar as rice is the main source of protein for most of the population. Htain Lin Tun et.al (2007) showed that the highest milled rice protein content was observed the Yezin Lone Thwe variety with the application of 125 kg N ha^{-1} at the Rice Division, Department of Agricultural Research (DAR), Yezin. This rate of fertiliser N is much greater than currently being applied, suggesting scope of improved nutritional status of the rural population.

Economic decisions for mineral nitrogen applied to cereals in Myanmar

When adding a limiting nutrient (such as N) to a cereal crop the pattern of response is expected to be increasing at a decreasing rate (Harmsen 2000). Although much attention has been placed on 'closing the yield gap', there is likely to be a difference between the levels of N to maximise yield and profit (Montjardino et al. 2016, and Farquharson et al. 2016). Variability in yield response means that risk aversion by farmers can be important in making N decisions (Montjardino et al. 2013). The marginal costs and benefits of fertiliser use decisions for cereal crops need to be considered and discussed with Myanmar cereal growers, in the context of their personal circumstances and beliefs.

Whither a nutrient miracle?

Matsuda (2011) evaluated the intensification of rice production during 2000s in Myanmar based on farm-level surveys conducted in Ayeyarwaddy, Bago, Tanintharyi, Mandalay, and Magwe Divisions representing the three major agroecological zones - the delta, the coastal and the central dry zones. Nutrient applications in surveyed areas of rainfed lowland rice were in a range of 11-53 NPK ha^{-1} (5-36 kg N ha^{-1}) for yields of 1.1- 2.3 t ha^{-1}. He also revealed that rice production in China and Vietnam intensified much more than in Myanmar. However, fertiliser use efficiency, which is a major component of sustainability, was much higher in Myanmar than in China and Vietnam (Figure 2). With more emphasis on sustainability related potential rice yield, the author identified the directions of C, B, A with higher inputs may not be as sustainable as direction D if it can be achieved through an integrated approach (Matsuda, 2016).

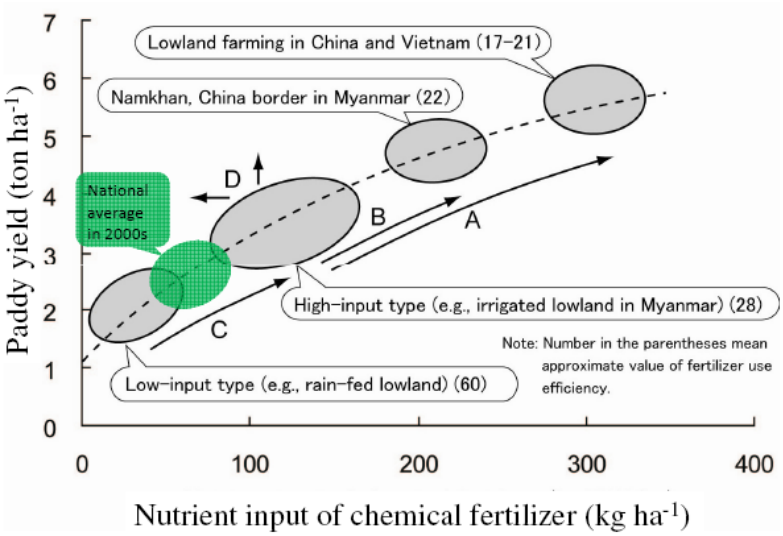

Figure 2. Fertiliser input and paddy yield in Myanmar (Matsuda, 2016)

Mineral nitrogen and future research in Myanmar

Research on mineral N and rice productivity and nutrition has been conducted for many years in Myanmar but most of it emphasised crop yield rather than economic and environmental impacts of mineral N. Yezin Agricultural University and The University of Melbourne have recently initiated a research project "Management of nutrients for improved profitability and sustainability of crop production in the central Myanmar" to determine best management practices and provide decision support tools for N fertilisation of rice and maize in central Myanmar. The project will develop a holistic understanding of biological, socio-economic and environmental impacts of N use at a pivotal time in the country's economic development related to recent reforms and overall policies that give priority to increased national cereal production and exports (Figure 3).

Figure 3. Yield responses and economic N rates in central Myanmar

Concluding remarks

Myanmar has large areas of land and generally sufficient water resources to expand rice production and the potential to increase crop yields. With a relatively small population the country has great potential to increase exports of rice as well as to secure its own food supply. This large potential will be supported by increased use of N fertiliser and will impact on regional demand for fertilisers and the supply of rice on the international market in the near future. At this pivotal time in Myanmar's development it is timely to elucidate the biophysical and socio-economic factors that lead to financially and environmentally viable intensification of rice production based largely on N fertilisation.

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