EFFECT OF *BIOGRO* BIOFERTILISER ON GRAIN YIELD AND NUTRIENT UPTAKE OF RICE GROWING ON A LIGHT-TEXTURED SOIL OF TAY NINH PROVINCE

Introduction

Rice production in Southern Vietnam, particularly on ancient alluvium of the Mekong River, is strongly associated with freshly-applied nutrients from mineral fertilisers due to a lack of soil nutrient reserves. However, the overuse of mineral fertilisers might create environmental hazard on those soils with low nutrient retention capacity.

The introducing of a group of microbes known as "plant growth promoting rhizosphere organisms-PGPR" to paddy fields has been reported to improve rice yield in many field trials in northern Vietnam (Kennedy and Hien, 2002). It is reported that the application of BioGro, a product containing many kinds of microbes, has given similar yields even when of the recommended N or P fertilisers were reduced by fifty percent. Therefore the BioGro product seems to be a promising solution to reduce investment costs and environmental risks associated with over-use of mineral fertilisers. This study was carried out with the aim of investigating the effect of multi-strain bio-fertiliser on rice yield.

Materials and methods

BioGro 2, a combination of 1N, HY, B9 and E19 strains, was applied to a grey degraded soil in a rice field of Thanh Dien village, Chau Thanh district, Tay Ninh province. The initial soil is a loamy sand, pH (H_2O) (1:5) 5.31, organic matter content 1.5%, cation exchange capacity 4.08 $cmol_c$ kg^{-1}, exchangeable K 0.11 $cmol_c$ kg^{-1}. Field experiments were carried out in two consecutive crops in 2006 as the first and the second rainy seasons. Trau Nam, a local variety with duration of 110 days, was used as the test crop. Different application rates of nitrogen (N) and phosphorus (P) were used to investigate the response of the rice crop and the interactions between bio-fertiliser and nutrients. Two levels of BioGro 2 inoculant were added: without and with 40 kg ha^{-1} to the seeds (at nursery bed) and 200 kg ha^{-1} to the field at transplanting.

Nitrogen was added at five rates (0, 30, 60, 90 and 120 kg N/ha) in the first experiment. Phosphorus (P) and potassium (K) were added at 30 kg P_2O_5 ha^{-1} as fused-magnesium phosphate and 60 kg K_2O ha^{-1} as KCl. In the second experiment, four P rates: 0, 10, 30, and 60 kg P_2O_5 ha^{-1} (from fused magnesium phosphate) were applied. N and K were added at 90 kg N ha^{-1} as urea and 60 kg K_2O ha^{-1} as KCl.

A split-plot design was used for both experiments where the BioGro rate was set at the main plots and N or P rate was randomised on the main plot as sub-plots. All treatments were replicated four times. Unit plot size was 5.1 m x 3.9 m = 19.89 square meters. Planting space was 15 cm x 15 cm, equivalent to 34 x 26 planting holes per plot.

All the data were analyzed at the University of Sydney using the statistical program GenStat version 7 (Payne *et al*., 2003) and grain yield response data were interpreted using differential calculus (Gomez and Gomez, 1984).

Results and discussion

Effects of BioGro 2 and N rate on yield and nutrient uptake of rice

In the first rainy season, the application of BioGro 2 increased both grain and straw yields. Grain yield was increased by 102 kg ha^{-1}, significant at 10% probability. Grain yield significantly ($P< 5\%$) increased due to N fertilisation up to 90 kg N ha^{-1}. Beyond this N rate, there was no significant increase in grain yield. A similar trend was observed in straw yield.

Estimated grain yield response due to N fertilisation was quadratic in nature with and without BioGro (Figure 1). A similar trend was found in straw yield response. The N rates for maximum grain yields with and without BioGro 2 were obtained by differentiating the quadratic N response equation following the method of Gomez and Gomez (1984). The N rate for maximum grain yield with BioGro 2 was 103 kg N ha^{-1} while it was 143 kg N ha^{-1} without BioGro 2. The maximum estimated grain yields were 3.21 and 3.18

t ha^{-1} with and without BioGro 2, respectively. This information indicates that BioGro 2 application has the potential to save 40 kg N ha^{-1} without affecting rice yield in the experimental site of Chau Thanh district, Tay Ninh province.

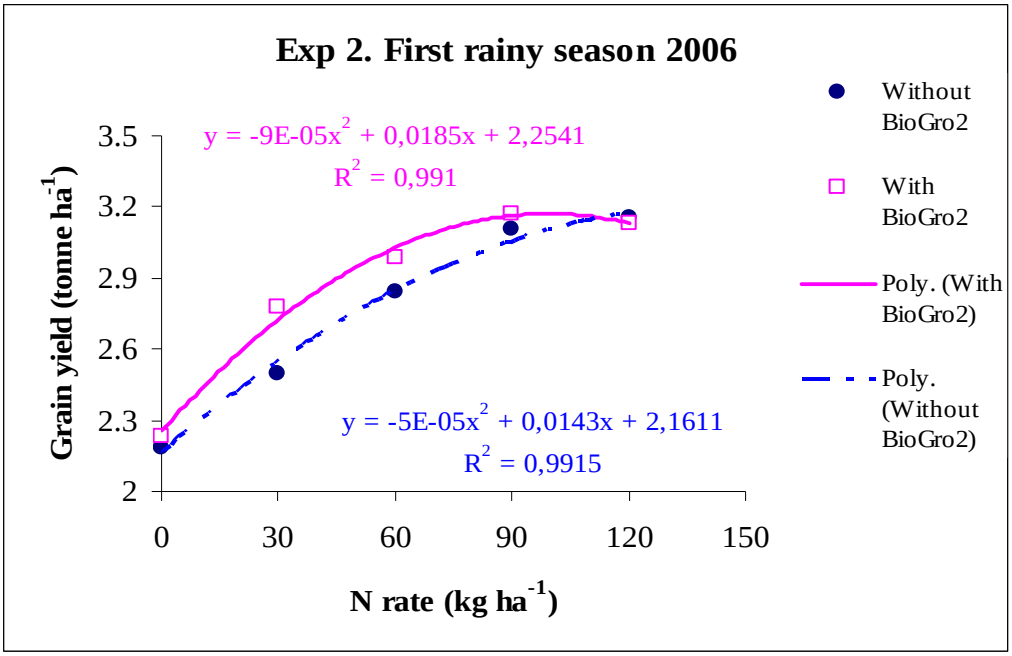

Figure 1 Estimated grain yield response of Trau Nam rice added N with and without BioGro 2, Chau Thanh district, Tay Ninh province, first 2006 rainy season.

In the second rainy season, the effect of BioGro 2 on grain yield improved compared with the first season and was statistically significant at 5% probability level. Grain yield increased 235 kg/ha over N rates when BioGro 2 was added. Similar to the previous season, grain yield was significantly (P<5%) increased due to N fertilisation, being highest at 90 kg N ha^{-1}. Beyond this N rate, there was a reduction in grain yield. Although BioGro 2 positively affected straw yield, there was no significant difference at 5% probability level. N fertilisation increased straw yield up to 90 kg N ha^{-1}.

Estimated grain yield response due to N fertilisation in the second season was also quadratic in nature with and without BioGro 2 (Figure 2). At all N rates, grain yield was higher when BioGro 2 was added. The N rate for maximum grain yield with BioGro 2 was 93 kg N ha^{-1} while it was 97 kg N ha^{-1} without BioGro 2. The maximum estimated grain yields were 3.48 and 3.26 t ha^{-1} with and without BioGro 2, respectively. This information indicates that BioGro 2 application has the potential to save 4 kg N ha^{-1} and gain an increase in rice grain yield of 223 kg ha^{-1} at the experimental site of Tay Ninh province, Southern Vietnam. This yield increase equals VND 650,000/ha. In order to obtain maximum estimated grain yield when no BioGro 2 was added, plots receiving BioGro 2 would need only about 37 kg of N ha^{-1} (estimated), saving 60 kg N ha^{-1} after two consecutive BioGro 2 applications. This indicates the important role of BioGro 2 in rice production on this soil type.

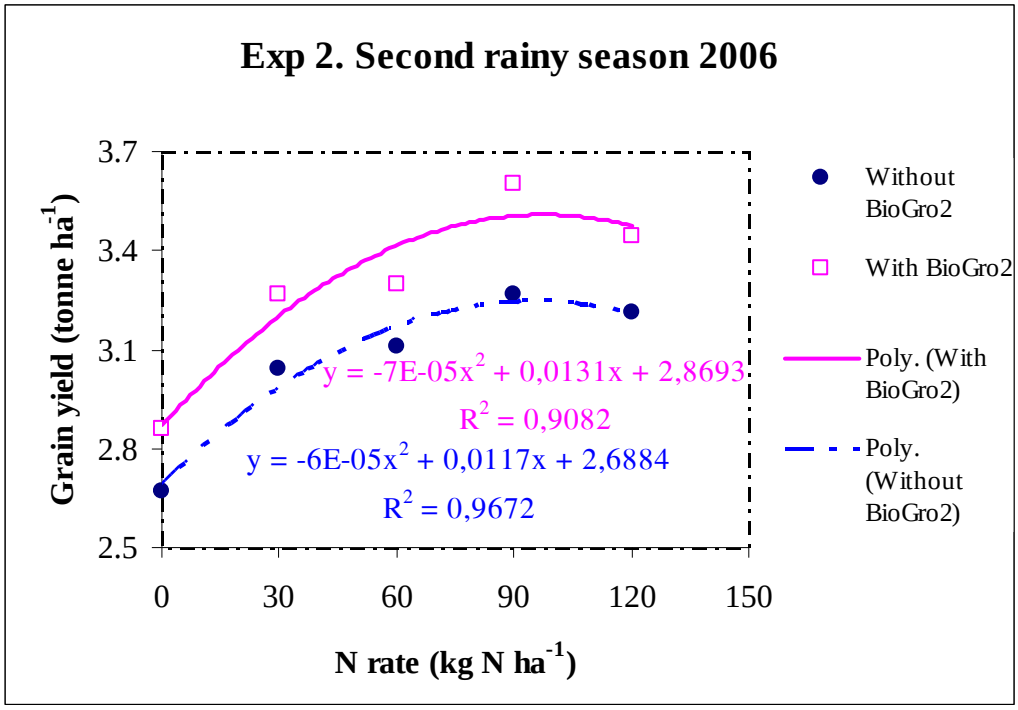

Figure 2. Estimated grain yield response of Trau Nam rice added N with and without BioGro 2, Chau Thanh district, Tay Ninh province, second 2006 rainy season.

In the first rainy season, BioGro 2 application significantly increased N content (%) in grain without fertiliser N, while its effect was not significant with fertiliser N. The effect of BioGro 2 was not significant on N content (%) in straw or on P content (%) in either grain or straw. In the second rainy season, BioGro 2 application significantly increased N content (%) in grain and straw. There was an interaction effect between BioGro 2 and N rate on N content (%) in grain at 5% probability level.

Total N uptake significantly (P<5%) increased due to both BioGro 2 and N rates up to 90 kg N ha^{-1}. Total P uptake was not significantly different when BioGro 2 was added, but N fertilisation significantly (P<5%) increased P uptake up to 60 kg N ha^{-1}.

The effects of BioGro 2 and N rates were not significant on P content (%) in either grain or straw, but total P uptake was significantly different when BioGro 2 was added. P uptake in grain significantly increased with N rate up to 90 kg N ha^{-1}, but total P was significantly different with the control when N was added.

Effects of BioGro 2 and P rate on yield and nutrient uptake of rice

In the first rainy season, the application of BioGro 2 slightly increased grain and straw yields although they were not statistically significant. The failure of BioGro 2 to increase grain yield significantly might be due to the high N rate (90 kg N ha^{-1}) used in this experiment as indicated in the experiment above. P application significantly increased grain and straw yields at rates up to 60 kg P_2O_5 ha^{-1}. This P response could be due to the low soil fertility status of the experimental field. The soil has a light texture and P buffering capacity is definitely low.

Although only four P rates were used in this experiment, data analysis shows that yield response is well-fitted to a quadratic equation (Figure 3). In the first season, grain yield was greatly increased at the highest P rate.

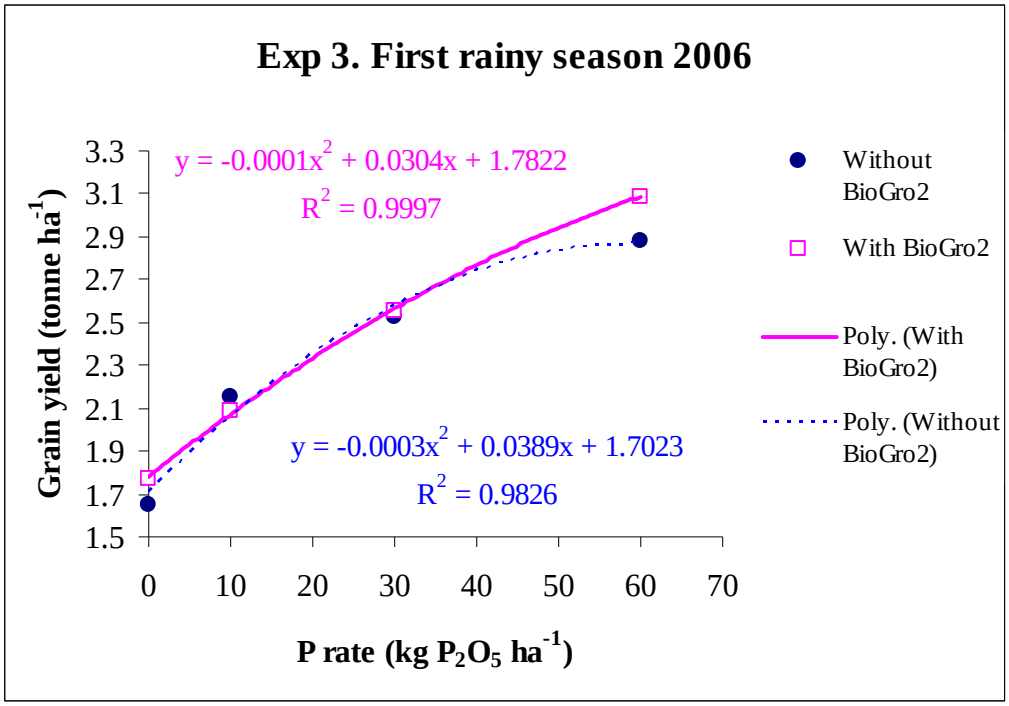

Figure 3. Estimated grain yield response of Trau Nam rice added P with and without BioGro 2, Chau Thanh district, Tay Ninh province, southern Vietnam, first rainy season 2006.

In the second rainy season, the application of BioGro 2 significantly increased grain and straw yields at 5% probability level although the same N rate (90 kg N ha^{-1}) was used. This indicates a positive effect of continuous application of bio-fertiliser. P application significantly increased grain and straw yields. At any P rate, BioGro 2 improved grain yield over the control (Figure 4)

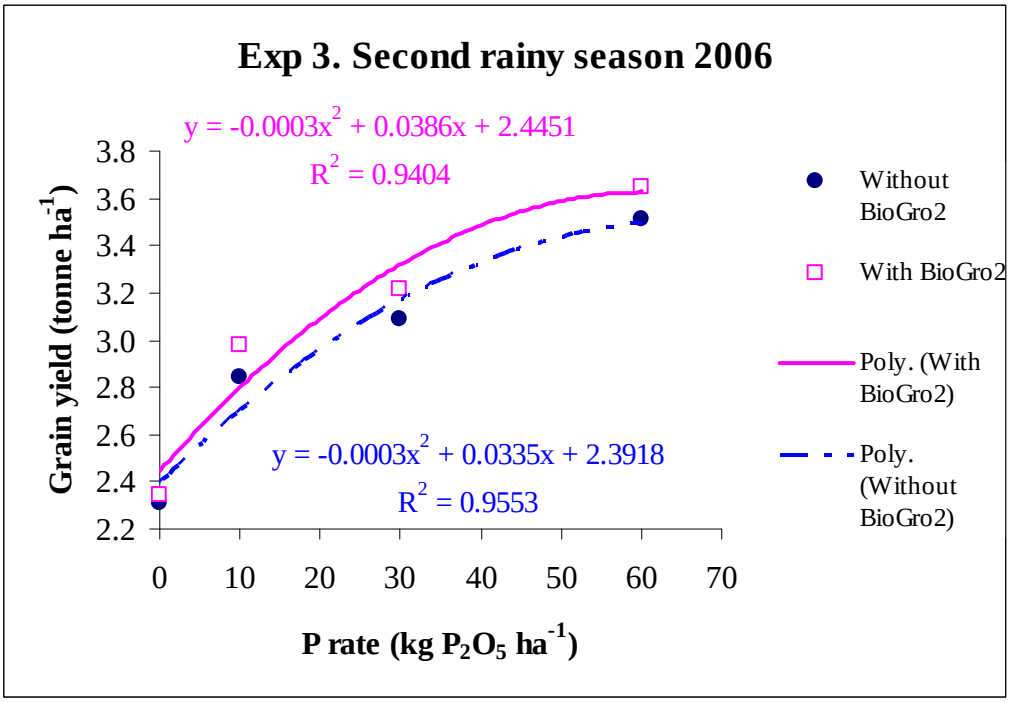

Figure 4. Estimated grain yield response of Trau Nam rice added P with and without BioGro 2, Chau Thanh district, Tay Ninh province, southern Vietnam, second rainy season 2006.

BioGro 2 application did not increase N and P content (%) in grain and straw nor total N and P uptake in the first season. Although BioGro 2 application did not increase N and P content (%) in grain and straw in the second season, total N uptake significantly increased.

In response to different P rates, total N and P uptake significantly ($P<5\%$) increased up to 60 P_2O_5 ha^{-1} in the first season. In the second season, P application significantly increased grain P content, and hence increased total P uptake.

Conclusions

BioGro 2 has a positive effect on grain yield and nutrient uptake of rice grown on a light- textured soil. The interaction with N or P fertilisation improves its efficacy. The effectiveness of BioGro 2 on rice yield and nutrient uptake increased at the second application and this implies a potential use of bio-fertilisers in rice production. The amount of required N fertiliser will be substantially reduced when BioGro 2 is added. A similar, but lesser, trend occurs with P fertiliser requirements.