Dipping rice seedlings in phosphorus (P)-enriched slurry at transplanting increases yield and avoids cold stress under P-deficient soils in the tropics

Phosphorus (P) deficiency is a major yield constraint for lowland rice production in Sub-Saharan Africa. Plant P uptakes are restricted not only by low P content in soils but also by high P-fixing capacity with abundant Al- and Fe-oxides in soils in the region. To overcome this constraint, we examined the effect of dipping seedling roots into a P-enriched slurry before transplanting (P-dipping) as shown in Figure 1.

First, we identified that initial rice growth can be substantially improved by the P-dipping (Fig. 2). The optimal duration of dipping and the P concentration in the slurry are less than 2 hours and 1.8%–2.6%, respectively. We further clarified that P-dipping can facilitate plant P uptakes by creating a soluble P hotspot at the plant base or near the root zone even in high P-fixing soils where P incorporation has no effect on rice growth (Fig. 3). Then, subsequent on-farm trials confirmed that P-dipping can significantly increase both grain yield and applied P use efficiency in the typical P-deficient lowlands of Madagascar (Fig. 4). The effect of P-dipping was particularly significant at a high-elevation and cool climate site, where the improved grain fertility is attributable to the avoidance of cold stresses at the reproductive stage because the technique shortens days to heading by 14 days compared to control (no fertilization) and by 6 to 9 days compared to conventional P application via broadcast.

Because lowland rice production in Sub-Saharan Africa is widely subjected to environmental stresses such as low temperature, water shortage at the end of the rice growing seasons, and highly P-deficient soils, P-dipping can be an efficient P fertilization technique for resource-limited farmers in the region.

(Y. Tsujimoto, A.Z. Oo, K. Kawamura, T. Nishigaki, N. Rakotoarisoa [FOFIFA])

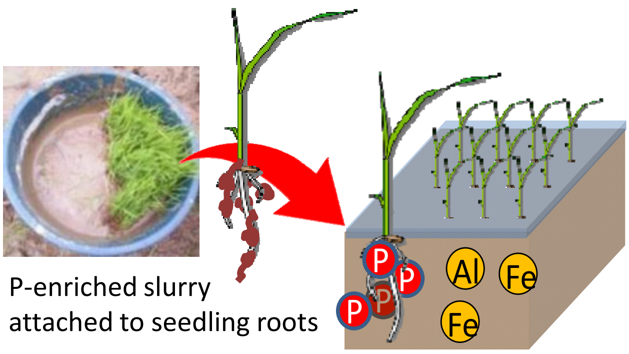

Fig. 1. An illustration of the P-dipping technique

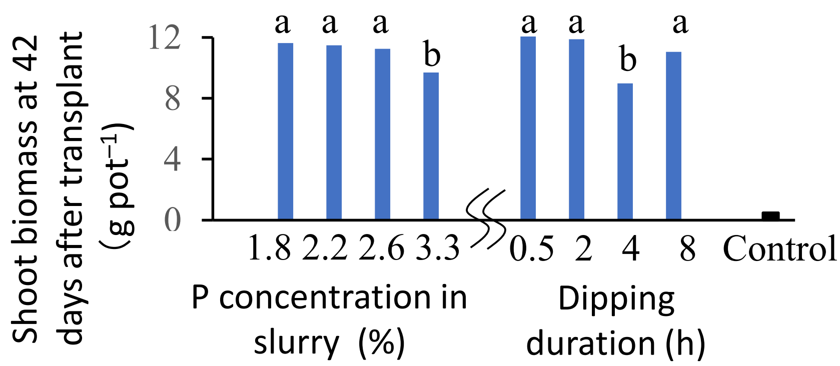

Fig. 2. Effect of P concentration in slurry and duration of P-dipping on initial plant growth

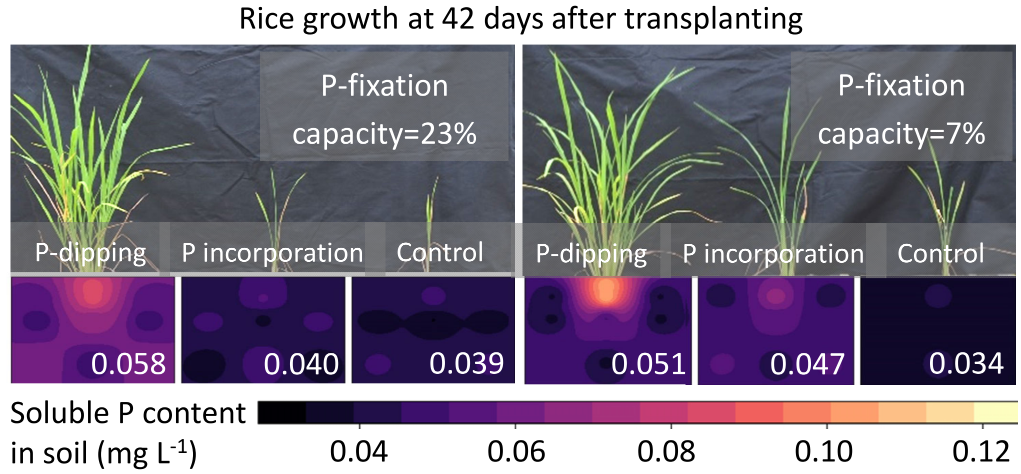

Fig. 3. Effect of P-dipping on plant growth and spatial distribution of soluble P content in the soils differing in P-fixing capacity

Both P-dipping and P incorporation treatments applied P at 40 mg pot^{-1}. The numeric number in the spatial map indicates the average soluble P content (mg L^{-1}) in the pot.

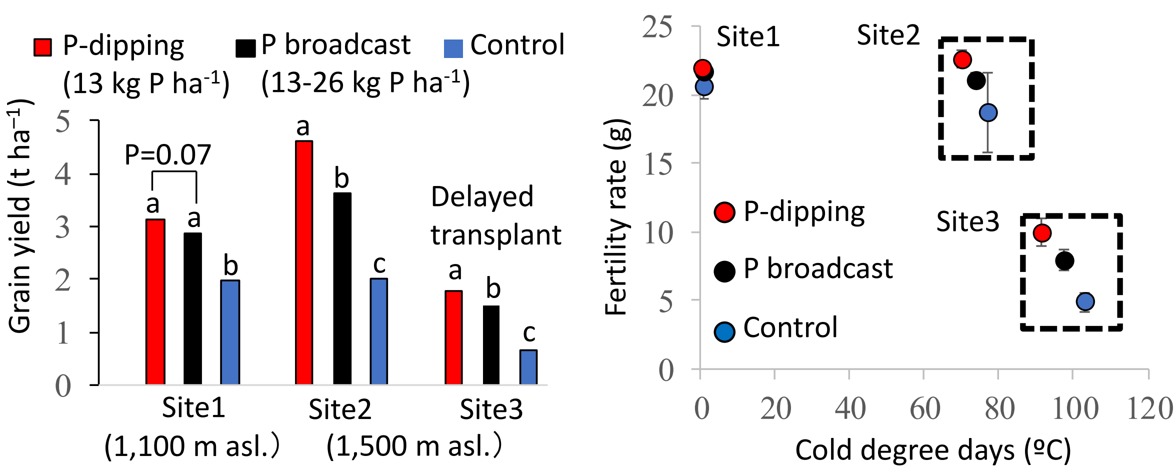

Fig. 4. Effect of P-dipping on grain yield and on cold degree days and fertility rate

Cold degree days is the sum of daily mean temperatures below 22 ºC from 15 days before to 7 days after heading. Fertility rate is the product of filled grain weight and filled grain rate.