Localized phosphorus application via P-dipping is effective in avoiding flooding damage for lowland rice production

To achieve higher production with minimal environmental impact in sub-Saharan Africa (SSA), it is crucial to make technical transitions from low-input to nutrient-use-efficient production systems. P-dipping, a localized phosphorus (P) application on seedling roots, is a potential approach to enable such a transition for lowland rice production. However, empirical evidence on the effectiveness of this approach in smallholders' heterogeneous field conditions is lacking. Therefore, 18 on-farm trials were implemented by applying three P application treatments (zero P; P broadcast at 13.1 kg P ha^{-1}; P-dipping at 13.1 kg P ha^{-1}) with and without N top-dressing (60 kg N ha^{-1}) under a range of topographic, edaphic, and climatic conditions in the highlands of Madagascar.

The P-dipping method had greater yields, exceeding by 1.1 t ha^{-1} vs. zero P and by 0.5 t ha^{-1} vs. P broadcast on average under the non-N-applied condition. The yield advantage of P-dipping was enlarged with N application, and thus, the effect of N on grain yield was greater in P-dipping than in zero P or P broadcast (Fig. 1). The P-dipping effect was increased when the fields had erratic water levels after transplanting, which was associated with vigorous initial growth and avoidance of submergence stress (Fig. 2). Multiple regression analysis detected that the effect of P-dipping on grain yield was prominent not only in fields with initial submergence stress but also in fields at high elevation/cool climate site and late-transplanted fields at low elevation/warm climate site where P-dipping alleviated late-season low-temperature stress by shortening days to heading (Fig. 3). This study revealed that the effect of P-dipping is consistent in various P-deficient soils and is enhanced by combining with N topdressing and when fields are prone to late-season cold stress or early-season submergence stress. The results of this study show that P-dipping has the potential to improve fertilizer use efficiency and help farmers cope with frequent flooding. The technology is expected to contribute to stable and sustainable rice production in sub-Saharan Africa as its use expands.

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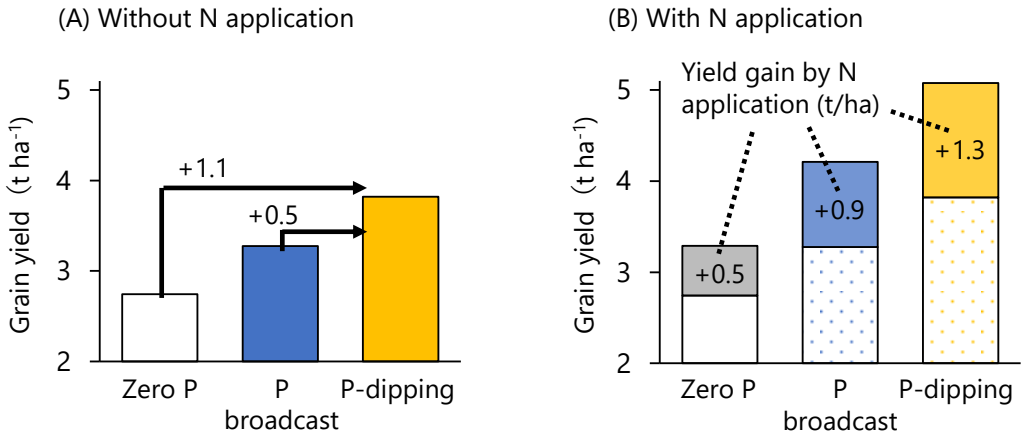

Fig. 1. Yield gain by P-dipping without N (A) and with N application (B)

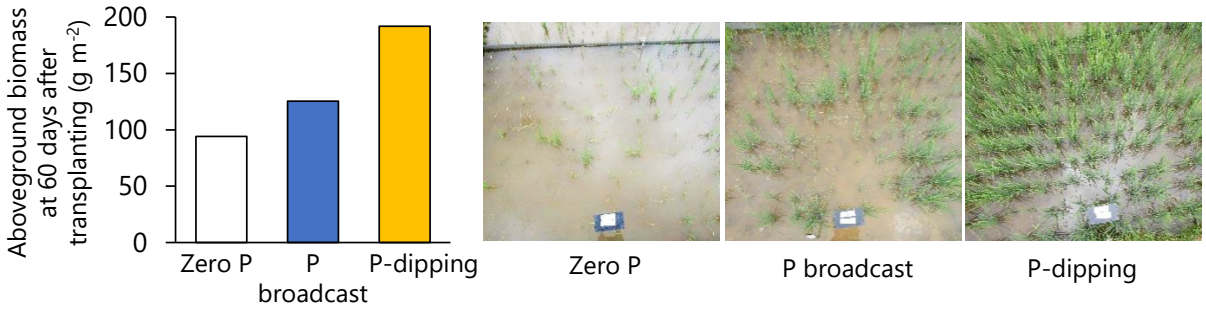

Fig. 2. Effect of P-dipping on the aboveground biomass at 60 days after transplanting and on submergence stress avoidance

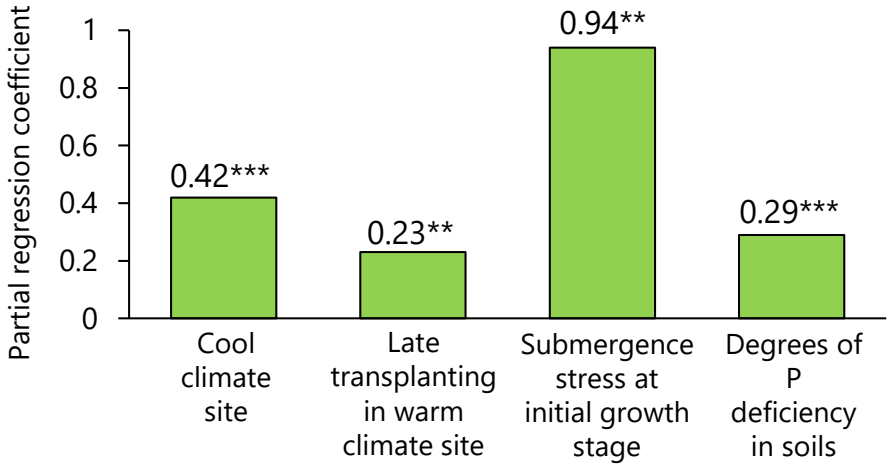

Fig. 3. Determinant factors with their partial regression coefficients for the field-to-field variations in the P-dipping effect on rice yield

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