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Editorial Open Access

# Improving Phosphorus Nutrition of Upland Rice through Native Arbuscular Mycorrhiza (AM)

**Dipankar Maiti***

Central Rainfed Upland Rice Research Station, (ICAR – Central Rice Research Institute), PB 48, Hazaribag-825 301, Jharkhand, India

## Editorial

Upland rice (*Oryza sativa* L.) is mostly grown under rainfed, drought prone ecology in aerobic soil condition and is direct seeded. The soils are generally poor in organic matter content, water holding capacity and acidic in nature. A majority of uplands under rice cultivation in India consists of red Alfisols and lateritic soils. These render upland rice poor in acquisition of less mobile nutrients of which phosphorus (P) is most important. This is because, beside formation of poorly soluble complexes of P with iron and aluminum in acidic soil [1], even available P forms remain adsorbed on soil particles making it inaccessible to plant from beyond P depletion zone which is created around effective root absorptive area [2]. This adsorbed P is very slowly diffusible unlike nitrogen and potassium and hence, remained inaccessible unless intercepted by roots. The external mycelia network of arbuscular mycorrhizal fungi (AMF) which is connected to colonized (AMF) plant through roots, serves as extended root surface up to 8 cm beyond root zone [3]. This mycelia network of AMF promotes acquisition of P from outside P depletion zone by intercepting the adsorbed P which is otherwise (under no AM association) not accessible to plant. The soil environment (aerobic condition) of uplands is favorable for AMF activities. Moreover, due to comparatively poor adoption of intensive agriculture in upland ecology, the soil system is less disturbed maintaining the soil micro-flora diversity, including that of AMF, almost intact [4]. The native AMF flora of upland ecology has been found to be efficient and upland rice is generally responsive to AM [5]. This makes the researchers to think of addressing the constraint of poor P nutrition of upland rice through exploiting native AMF flora. Use of native flora has some added advantages like: (1) these are more adaptive to the target ecology and do not face rejection by the native flora, (2) have less negative ecological consequences in terms of invasive species introduction as unintended contaminants [6].

Harnessing ecosystem services of native AMF for improving P nutrition of upland rice was attempted by (1) enhancing native AMF activities in soil through adopting AM-supportive crop culture methods and (2) use of AM-inoculum of native origin.

(1) *Enhancing native AMF activities in soil through adopting AM-supportive crop culture methods:* Improved agronomic managements and rice based cropping systems were evaluated and fine-tuned in favor of native AMF to identify AM-supportive components. Among agronomic managements, several off season tillage schedules and P fertilization doses were screened and following AM-supportive components were identified which improved plant (upland rice) P nutrition with concomitant increase in grain yield through encouraging native AMF activities.

AM-supportive crop culture components for upland rice identified were;

(i) Spacing off season tillage (OFT - an agronomic recommendation for weed and soil pest management) schedules by at least 13 weeks reduces [7] deleterious soil disturbance induced (SDI) effect [8] on established mycorrhizal mycelia network in soil. For rainfed uplands, two options of off-season tillage schedules (summer tillage alone and initial tillage after harvest + summer tillage) have been recommended for maintaining optimum activities of native AMF [7].

(ii) Two AM-supportive rice based cropping systems/rotations were identified viz. (a) rice + pigeon pea (*Cajanas cajan*)/ rice + ground nut (*Arachis hypogea*) intercropping systems [9] and (b) two years crop rotation of maize (*Zea mays*) relay cropped by horse gram (*Dolichos biflorus*) in first year and rice in second year (M-HG/R) [10]. For rice-legume intercropping systems, however, pulses need to be rotated to avoid sick plot (soil borne diseases like wilt) development.

(iii) P fertilizer application in rice could be reduced by 30% (over recommendation) under AM-supportive M-HG/R rotation [11]

(2) *Use of AM-inoculum of native origin:* Methodology of on-farm production of mass inoculum (MI) of native AMF was developed [12]. This involved preparation of nucleus inoculum (NI) under sterile condition on a suitable substrate using native AMF spores and multiplying NI in partially sterilized (by soil solarization) micro-plots on roots of *Sorghum* as trap crop to produce MI.

Integration of above components showed to result in synergistic/ additive effects in terms of AMF colonization (+22.7 to +42.7%), plant P acquisition (+11.2 to +23.7%) and grain yield of upland rice variety Vandana (+25.7 to +34.3%) [13].

Efforts are on-going to fine tune on-farm production methodology of native AMF based MI and developing P fertilization schedule (alternative sources) under application of AM-based inoculum including microbial consortium (AMF + PSB + growth promoters) at Central Rainfed Upland Rice Research Station (ICAR- Central Rice Research Institute), Hazaribag, Jharkhand, India.

Twin attributes of AM symbiosis *viz.*, lack of host specificity of AMF and variation in AM responsiveness among genotypes of plants [14] indicates possibility of genetic manipulation of plant in favor of native AMF. Upland rice ecology satisfies the prerequisites such as (i) less disturbed native population (AMF) [4] and (ii) responsiveness of

***Corresponding author:** Dipankar Maiti, Central Rainfed Upland Rice Research Station, (ICAR – Central Rice Research Institute), PB 48, Hazaribag-825 301, Jharkhand, India, E-mail: dipankar_maiti@live.in

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upland rice varieties to AMF, for genetic manipulation in upland rice to further exploit native mycorrhizal benefits under target agro-ecology.

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