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Nitrogen Dynamics of Grain Legume–Weedy Fallow–Flooded Rice Sequences in the Tropics

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ABSTRACT

Dry-season (DS) grain legume–weedy fallow–wet-season (WS) flooded rice is a common cropping sequence in the rainfed lowlands of tropical Asia. To better manage N in this cropping system, we need to understand N dynamics and balances as influenced by the aerobic–anaerobic soil aeration sequence, legume cropping, biological N_2 fixation (BNF), and recycling of legume residues. To understand N dynamics under a range of N derived from BNF (^{15}N-estimated), harvested in pods and left in residues, we conducted a 2-yr experiment on a Philippine Alfisol using cowpea [*Vigna unguiculata* (L.) Walp.], mungbean [*V. radiata* (L.) Wilcz.], nodulating and nonnodulating soybean [*Glycine max* (L.) Merr.], and weeds. The main portion of soil mineral N (0 to 60 cm) was NO_3 in the dry season and NH_4 in the wet season. The sum of soil NO_3 and soil N uptake at legume harvest exceeded the decrease in soil NO_3 from legume seeding to harvest by 81 kg ha^{-1}, indicating the continued production and legume uptake of soil NO_3. The large differences in total N of legumes (46 to 238 kg N ha^{-1}), however, were associated with differences in N derived from BNF (0 to 176 kg N ha^{-1}). When pod N was excluded, legume N balance was, in most cases, negative. The average soil N depletion was 40 kg ha^{-1} from nonnodulating soybean, compared with 8 kg ha^{-1} from N_2–fixing legumes. In terms of WS rice grain and N yields, legume cropping did not differ from weedy fallowing, despite greater (by up to 46 kg N ha^{-1}) quantities of legume residue N in some instances. Large amounts of legume residues, however, were associated with reduced legume grain yields, thus decreasing the harvestable grain N output. Fertilizer N, compared with residue N, had a greater effect on WS rice grain and N yields. The use of legumes in lowland rice-based cropping systems must maximize harvestable N while effectively using soil, BNF, and applied N sources.

GRAIN LEGUMES are major upland crops in the tropical rice lowlands of Asia during the dry season immediately following single or double wet-season flooded rice crops. While legumes are considered to contribute substantial amounts of N through biological N_2 fixation, data on actual N gains due to legume cropping in these rice lowlands are not available. Such information is particularly relevant for managing legumes in these lowlands, because of the potential for large soil NO_3 buildup during the dry season (George et al., 1993) and the likelihood of soil NO_3 loss during the dry-to-wet season transition (George et al., 1994). The soil N balance following harvest of N_2–fixing grain legumes can be positive (Peoples and Craswell, 1992), but even with a large N input from BNF, the N balance may be negative when N removal through grain harvest is substantial (Chapman and Myers, 1987; George et al., 1992).

Research on the N dynamics and balances in legume–lowland rice sequences has been primarily with legumes grown during the dry-to-wet (DTW) transition period just prior to a WS rice crop. However, in most of the rainfed rice lowlands where legumes immediately follow the preceding WS rice crop, the land is usually left to weeds during the post-legume DTW period. Dry season legumes with subsequent fallow periods may have different effects on soil N and on the N nutrition of WS rice compared with legumes grown immediately before the WS rice.

Post-legume mineral N levels in lowland rice soils have rarely been measured (Buresh et al., 1989). In non-rice soils, residual soil mineral N is reported to be greater after legumes than after other crops (Doughton and MacKenzie, 1984; McEwen et al., 1989; Strong et al., 1986). Significant amounts of NO_3 accumulate in fallow soils following legumes as compared with fallow soils following other crops (Buresh and De Datta, 1991; Strong et al., 1986). Post-legume NO_3 accumulation is not substantially beneficial to rice, since most of the NO_3 will be lost when the soil is flooded for rice cultivation (George et al., 1994).

In previous reports (George et al., 1992, 1993, 1994), we have developed a conceptual understanding of the dynamics of soil N and legume BNF in rice lowlands and have demonstrated with field data how NO_3 accumulation and loss is inextricably linked with soil management during the dry season and crops grown during the dry-to-wet transition season. Growing of grain legumes as cash and/or food crops during the dry season is a common practice, yet no quantitative data exist on the effects of DS legumes

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Abbreviations: BNF, biological N_2 fixation; DS, dry season; DTW, dry-to-wet (season transition); WS, wet season.