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Resource Use and Plant Interactions in a Rice-Mungbean Intercrop

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ABSTRACT

Intercropping of upland rice (*Oryza sativa* L.) with short-duration grain legumes has shown promising productivity and resource use efficiency. To better understand intercrop relationships, we used above- and underground partitions, residue removal, and plant removal to investigate the interactions between upland rice (120-d crop duration) and mungbean [*Vigna radiata* (L) Wilczek, 65-d crop duration]. Treatments were evaluated during two rainy seasons on an unfertilized Typic Tropudalf at Los Baños, Philippines. Nitrogen uptake by intercropped rice (33.4 and 41.1 kg N ha^{-1}) approximated that of sole rice (35.4 and 38.1 kg N ha^{-1}). Intercropped rice yielded 73 to 87% of sole rice and intercropped mungbeans yielded 59 to 99% of sole mungbean. Root barriers did not affect rice N uptake or dry matter accumulation prior to the maturity of the mungbean, but reduced N uptake, dry matter, and grain yields substantially by the time of rice harvest. Sole rice with every third row removed at mungbean harvest had N, grain, and dry matter yields similar to the intercropped rice with every third row occupied by the legume. Sole rice with every third row vacant during the entire growing season yielded similarly (2.6 Mg h^{-1}) to sole rice (2.3 Mg h^{-1}) and intercropped rice (2.0 Mg h^{-1}). There was no evidence that N transfer from the legume to the rice increased N availability to rice above that expected with a sole rice crop with the same planting scheme. Rice yield compensation in the intercrop was apparently due to the increased soil volume for N extraction and increased aerial space available after mungbean harvest.

IN MOST PARTS of southeast Asia, upland rice is grown by subsistence farmers with little or no application of inorganic fertilizers. Since the soils are generally of low inherent fertility and rainfall is variable, rice yields are modest (usually about 1.0 Mg ha^{-1}). Many farmers intercrop rice with maize (*Zea mays* L.) or cassava (*Manihot esculenta* Crantz) [Int. Rice Research Inst., 1974 (p. 16–24), 1975 (p. 324–326); McIntosh et al., 1984]. Such intercropping generally ensures production stability but reduces rice yield because of intercrop competition for light and soil N. Intercropping of rice with determinate, short-duration legumes is now being explored as a system to intensify and sustain production through efficient use of available nutrients, water, and radiation during the wet season [IRRI 1984 (p. 421–424), 1986 (p. 408–410), 1987 (p. 483–486); Torres et al., 1989]. The intercrops exhibited higher total yields and greater stability of production in these studies, presumably due to more efficient resource use.

When legumes and non-legumes are intercropped, the non-legume species sometimes performs better than it would in monoculture (Agboola and Fayemi, 1972; Burton et al., 1983; Wilson and Wyss, 1937, Willey, 1979b) possibly because of the additional N supplied by the legume. The processes by which the non-legume obtains extra N, however, are not well understood.

Nitrogen transfer from legumes to associated non-legumes is often mentioned as a potential benefit of cereal-legume intercrops. Eaglesham et al. (1981) and Patra et al. (1986), using ^{15}N-labeled fertilizer, presented evidence that N transfer occurred in a cereal-legume intercrop. Nitrogenous compounds may be excreted from the nodulated root systems of intercropped legumes (Virtanen et al., 1937; Butler and Bathurst, 1956). Soluble N may be leached from attached legume leaves, or released by the decay of fallen leaves (Whitney and Kanehiro, 1967; Whitney et al., 1967).

The yield advantage of any intercrop is attributed to below- and above-ground plant interactions. These interactions may be competitive, neutral, or complementary (Willey, 1979b). Snaydon and Harris (1979) pointed out that below-ground interaction is more important than above-ground interaction in achieving intercrop yield advantages. Below-ground interaction is more intense than that above ground (Donald, 1958; Aspinall, 1960; Snaydon, 1971; Newberry and Newman, 1978). However, Willey and Reddy (1981) observed an intercrop yield advantage to pearl millet [Pennissetum americanum (L.) Leeke] and groundnut (*Arochis hypogaea* L.) due to above-ground interaction between the respective canopies.

The relative importance of below- and above-ground intercrop interactions is likely to vary depending upon the temporal and spatial differences in resource use by component crops. The objective of this study was to compare above- and below-ground interactions between intercropped upland rice and mungbean, and to examine their effect on N uptake and crop productivity.

MATERIALS AND METHODS

Two field experiments were conducted at the International Rice Research Institute (IRRI) experimental farm, Los Baños, Laguna, Philippines (mean annual rainfall 1892 mm) during the rainy seasons of June to September 1986 and 1987. The soil at the experimental site was an isohyperthermic Typic Tropudalf of silty clay texture. Chemical properties of the soil before planting in 1986 were pH, 6.0; Organic C, 15.0 g kg^{-1}; total N, 1.18 g kg^{-1}; available P (Bray 2), 41 g Mg^{-1}; exchangeable K, 1.07 cmol kg^{-1}; and cation exchange capacity, 20.0 cmol kg^{-1}.

Experiment 1. The nine cropping treatments (Table 1) used in Exp. 1 and their planting scheme appear in Fig. 1. In intercrop treatment (T1), the mungbean residues were left on the soil surface at mungbean harvest. In Treatment 4 the abscised leaves were removed repeatedly from the soil surface as they dropped to the surface. Abscised leaf removal was initiated 40 d after sowing and continued through mungbean harvest. Below-ground interaction between intercropped rice and mungbean roots (T1) was prevented in (T2) by placing sheets of galvanized iron vertically between rows of the two crops to a depth of 50 cm. Root interaction

Abbreviation: LER, land equivalent ratio.

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