Integrated nutrient management for enhanced rice productivity in coastal saline soils of Eastern India

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In coastal saline areas of Eastern India, rice is grown under rainfed condition during the wet season and under irrigated condition using harvested rainwater during the dry season. During the wet season, rainfall distribution is often erratic and the crop suffers from abiotic stresses (salinity, drought and submergence) and natural calamities (storms and cyclones), resulting in high risks and low productivity. Farmers generally grow traditional rice varieties with hardly any chemical fertilizers, particularly in intermediate lowlands (0-50 cm water depth), where application of chemical fertilizers is often not feasible. Even in shallow lowlands (0-30 cm), very little fertilizers are used because of high risks and low economic returns. With the introduction of improved salt-tolerant rice varieties in recent years, integrated nutrient management (INM) combining inorganic and organic sources of nutrients is becoming increasingly important for enhancing and stabilizing rice productivity and maintaining soil health.

In an ICAR-IRRI collaborative project under the Consortium for Unfavorable Rice Environments funded by the Asian Development Bank and the CPWF PN7, site-specific INM trials were conducted in farmers' fields in Ersama block of Jagatsinghpur district of Orissa, India during 2004-2006. In the wet season, two separate trials were conducted 1) under shallow lowland: *Sesbania* green manure (GM) + prilled urea (PU) at 20 kg N ha^{-1} at panicle initiation, *Azolla* + PU at 30 kg N ha^{-1} (20 kg as basal and 10 kg at tillering), *Sesbania* + *Azolla*, and PU at 60 kg N ha^{-1} in three splits (30 + 15 +15); and 2) under intermediate lowlands: urea super granule (USG) at 45 kg N ha^{-1} 10 days after transplanting, *Sesbania*, and farm-yard manure (FYM) at 5.0 t ha^{-1} + PU at 20 kg N ha^{-1} as basal. Under both conditions a no-N treatment was included as a control. The soil was sandy loam with organic C 0.35-0.58% and total N 0.04-0.06% for shallow lowland and loam/clay loam with organic C 0.9-1.3% and total N 0.1-0.12% for intermediate lowland trials. In the dry season, a third experiment was conducted to compare the performance of *Azolla* + PU at 50 kg N ha^{-1} (30 kg as basal and 20 kg at tillering) with PU at 80 kg N ha^{-1} applied in three splits (40 + 20 + 20) and no-N control. The soil was sandy loam/loam with organic C 0.65-1.04% and total N 0.07-09%. Rice varieties Pamkaj in shallow lowland and Lunishree in intermediate lowland during the wet season and Canning 7 and Annapurna during the dry season were used.

During the wet season in shallow lowlands, *Sesbania* GM + *Azolla* were as effective as PU at 60 kg N ha^{-1} and increased grain yield of rice by 30-40% over control. This treatment is of special significance because it does not include any chemical N fertilizer. In intermediate lowland, *Sesbania* GM was as effective as USG in 2005 but not in 2006, where *Sesbania* growth was poor due to initial drought and associated high salinity (soil ECe 8-11 dS m^{-1}). During the dry season, *Azolla* + 50 kg N ha^{-1} resulted in about 100% higher grain yield over control and 15% higher grain yield over prilled urea at 80 kg N ha^{-1}. *Azolla* saved 30 kg N ha^{-1} of chemical fertilizer and improved rice yield. The higher yields under these treatments was because of increase in the number of panicles m^{-2} and grains $panicle^{-1}$. Dissemination of *Azolla* biofertilizer and *Sesbania* GM technologies is on-going through on-farm demonstrations in target areas. Trials on *Azolla* during 2006 dry season showed a yield advantage of 21-35% over no-*Azolla* treatment.

In rainfed coastal ecosystems, most of the nutrient management practices have their own limitations and their effectiveness depends on rainfall distribution and associated abiotic stresses. Our results indicated that during the wet season *Sesbania* GM is promising for both shallow and intermediate lowland situations. However, establishment of green manure crop and subsequently its incorporation into the soil are difficult in drought years. *Azolla* biofertilizer is the most promising option during the dry season and can also be used effectively in shallow lowlands during the wet season, provided there is no problem of drought or floods. Farmers can produce their own *Azolla* inoculums in ponds and ditches that are common in coastal areas. The USG is also promising particularly in intermediate lowlands, where prilled urea is not so effective, but its use is limited by its availability and difficulties in application.