Methane and nitrous oxide emissions of rice and maize production in diversified rice cropping systems from a multi-seasonal measurement campaign

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Traditional irrigated double-rice cropping systems have to cope with less water availability. To quantify the shift in CH_4 and N_2O fluxes when changing from traditional to diversified double cropping-systems, an experiment rotating flooded rice with non-flooded "aerobic" rice and maize was conducted at the international rice research institute (IRRI) in the Philippines. Two automated static chamber-GC systems with a total of 27 chambers were used to measure CH_4 and N_2O fluxes continuously over three subsequent seasons (dry-wet-dry). Non-flooded crops were cultivated only in the dry season, during the wet season all fields were cultivated with flooded rice. The three crop rotation systems: (dry season-wet season) flooded rice-flooded rice, aerobic rice-flooded rice, maize-flooded rice were combined with three fertilizer treatments (N=3): zero-N (no fertilizer), conventional (130 kg ha^{-1}) and site-specific (90-190 kg N ha^{-1}, were N-addition rate was computed depending on chlorophyll content and differed between seasons [Wet<Dry] and crops [Maize>Rice]).

Turning away from flooded cropping systems lead to shifts in greenhouse gas emissions from CH_4 under wet to N_2O emissions under dry conditions. During both dry seasons the combined global warming potential (GWP) of CH_4 and N_2O for the non-flooded crops was lower compared to flooded rice as high CH_4 emissions under flooded conditions override N_2O emissions. Scaling GWP to yield favored maize over aerobic rice: maize cultivation in the dry season emitted 50-70% less kg CO_2 per produced Mg grain yield then flooded rice. CH_4 emissions during flooded rice cultivation in the maize-rice system, following a season with aerobic soil conditions, were ca. 50% lower when compared to the traditional flooded rice-rice system. Aerobic rice cultivation emitted about 15% less kg CO_2 per produced Mg grain yield then flooded rice, although produced grain yields from aerobic rice were about 40-60% lower. When combining all measured CH_4 fluxes from flooded rice cultivation over three seasons a fertilization effect was observed. Addition of nitrogen (urea) decreased CH_4 emissions by 28-38% when compared to flooded rice production without fertilizer application.

The maize-rice system shows mitigation potential in terms of low yield-scaled GWP (for maize grain production) during the dry season while decreasing CH_4 emissions during the wet season. Increasing prices for maize grain (for poultry etc.) and the lower water demands are important factors for the adoption of this system. Cultivation of aerobic rice also produces less CO_2-equivalent per Mg grain then flooded rice production though because of the lower (rice grain) yield, this system may only be of importance if water availability is the limiting factor. Although a fertilizer effect on CH_4 emission is controversially discussed, decreasing CH_4 emissions while improving yield scaled GWP by increasing yields indicates high mitigation potential for the fertilization of flooded rice systems with low N input, which are quite common e.g. in the Philippines.