Integrated on-farm crop diagnosis of upland rice yields in northern Thailand

The problem
- In Southeast Asia, swidden cultivation of upland rice (UR) is still an important component of remote montane farming systems, but yields in farmers' fields are generally low (1-1.5 t/ha) and quite variable.
- Under no-till cropping systems, local UR cultivars display yield potentials of 3 and 4 t/ha for early and late varietals, respectively (Van Keer et al., 1998). But such potentials are seldom reached due to the multiple interacting limiting factors characteristic of the unfavorable UR ecosystem.
- To reduce yield gaps, identifying and ranking these limiting factors and understanding their effects on UR culture functioning are a prerequisite to setting research priorities for improving current practices.

Research objectives
- To date and quantify UR yield differentiation under actual farmers’ circumstances and management practices.
- To characterize UR environmental conditions and farmers’ practices along the whole crop cycle.
- To identify, rank, and understand the main environmental and cropping system variables influencing UR crop production and causing major yield limitations.

The on-farm diagnostic survey for data collection and analysis
- A 4-year (1993-96) on-farm survey covering an extensive range of UR crop situations was conducted in a single highland village.
- Data on crop population status for two contrasting types of local UR cultivars, crop environmental conditions, and cropping practices were obtained through regular monitoring of 432 squares (1 m²) delimited at crop emergence in 63 farmers' fields.
- Phase realisation indices, which synthesize the effects of crop constraints during a given phase of UR yield buildup (Wey et al., 1998), were calculated and distribution patterns analyzed to assess the relative importance of successive growth phases in UR yield determination.
- To identify and to rank causes of UR yield differentiation, a principal component analysis with instrumental variables (PCAV; Lébreton et al., 1991) was carried out on 1993-96 pooled data as well as for individual year subdatasets.

The study site
Mae Haeng, a highland Lahu village (600-800 msl) in northwestern Thailand, is characterized by:
- A monsoon climate, a strong relief, deep granitic soils with clay-loamy texture and medium fertility, heterogeneous (2-10-year-old) types of fallow vegetation, and a wide range of weed species, diseases, and insect or other animal pests.
- Traditional swidden cultivation practices in UR no-input cropping systems with only gradually increasing range of weed species, diseases, and insect or other animal pests.

Dating and ranking the periods of yield differentiation
- For the reproductive phase, frequency distributions of phase realisation indices pinpoint pivotal points and spikelet differentiation as key periods of yield differentiation.
- During the vegetative period, poor crop biomass accumulation was of greater importance than low plant density. Vegetative biomass accumulation per plant influenced panicle and spikelet formation and spikelet differentiation as key periods of yield differentiation.
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Identifying and grading the causes of yield differentiation
- The analysis of pooled data reveals strong negative relationships for (i) plant density vs weed competition and late-maturing cultivars (having lower sowing densities); (ii) no. of plants per plant vs rice root aphid infestation; (iii) percentage of filled spikelets and 1000-grain weight vs 1995 wet season (dry spells). Weak negative relationships were found for no. of plants per plant vs slope angle, erosion, no. of successive UR crops, and early weed stress.
- The analysis of individual year subdatasets isolates rice root aphid infestation as the single major limiting factor having a strong and consistent effect on final UR grain yield.
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Conclusions
- UR yield differentiation was found to occur mainly during (i) biomass accumulation phase and (ii) the early part of the reproductive phase.
- The results of this agronomic survey support the validity of several common hypotheses on UR limiting factors (weed competition, drought stress, soil erosion). No important yield effect was found and no major soil nutrient limiting factor was diagnosed. Finally, this analysis showed that more attention should be paid to soilborne UR pests when prioritizing issues for the improvement of UR-based cropping systems in the northern Thailand highlands.