

## Beyond “Normal” LGP: Mapping Cultivar Adaptation in Variable West African Climates

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Determination of recommendation domains has long relied on average “normal” climate conditions (LGP: average length of growing period) and large-scale concepts of homogeneity like mega-environments. Here we utilize learnings from crop simulation models to devise alternate cultivar mapping methods based on more relevant phenological adaptation criteria, such as end of growing season dates. This is especially relevant in West Africa, one of the most climatically sensitive regions of the world, where continental effects magnify the rainfall downscaling problem and impede the translation of new climate information into tactical options for small-scale farmers.

Photoperiod (PP) sensitivity allows sorghum and millet landraces to match cycle duration with the expected length of the growing season. Mechanistic models can be used to understand and simulate GxExM interactions. Sensitivity analyses allow the identification of main performance factors at various levels of scale. In turn, models can be simplified for analysis of adaptation and potential adoption. On regional scales, determinants of phenology are more important than determinants of biomass partitioning, especially in small-scale farming where risk management largely relies on production stability. Fixing crop cycles on normal LGP often carries unacceptable risk and is potentially dangerous in variable climates, as indicated by widespread PP-sensitivity in native plants. Outscaling methods must reflect this diversity to limit rejection of improved, but unadapted germplasm.

A phenological adaptation index was defined that allows fast delineation of optimal cultivation zones for both PP-sensitive and PP-insensitive material. In West Africa regions of modal rainfall, a cultivar can be considered adapted if it flowers about 20 days, on average, before the end of rains. Adaptation maps based on that criterion take into account the uncertainty in sowing dates characteristic of the region (whereas the technique of matching cycle duration to LGP does not). For computation of end-of-season dates, data from 200+ synoptic and 600+ rainfall stations were collated. Start and end of season dates were computed with a simplified water balance budget. An index based on the time lapse between flag leaf expansion and end of rainy season date was computed for all data points, and spatialized using kriging.

Adaptation zones were computed for a range of cultivars from PP-sensitive to weakly PP-sensitive and PP-insensitive. For early maturing varieties, the adaptation strip migrates rapidly southwards when sowing is delayed with the (unpredictable) onset of rains. Contrastingly, photoperiodic varieties exhibit a slower shift with high degree of overlap between two distant sowing dates. The early maturing cultivar features large geographic adaptation, *provided that the onset of the season and sowing date can be predicted*. With delayed planting, it can cater to most agricultural regions (Sahelian and Sudanian and North Guinean). However it features weak temporal adaptation for any given site. Conversely, PP-sensitive germplasm can espouse temporal vagaries in climate, but is indentured to a specific agro-ecology (Sudanian or North Guinean). The width of the overlapping zone is indicative of the capacity of the crop to deliver on a wide range of planting dates – an interesting feature in variable and changing climates. The variability in the onset of rains, which triggers a seasonal cascade of (a)biotic and socio-economic constraints, remains an unresolved prediction challenge and a major explanation for the persistence of key adaptation traits such as photoperiod (PP) sensitivity. For tactical decisions, improved seasonal forecasting of the onset date of the rainy season remains therefore a pivotal target.

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