The West African target population of environments for grain sorghum: Varietal fit to agro-ecological zones

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Problematic. Breeders need tools to translate variable climatic conditions in dry environments into probable crop performance, and to translate genotype profiles into agro-ecological fit. This can be done by model-assisted characterization of target populations of environments (TPEs). West African sorghum cultivars require, in addition to drought tolerance, effective phenological mechanisms for temporal escape from drought and excessive humidity that would favour pests and diseases during sensitive development stages.

Approach. A simulation experiment was conducted to predict the potential and attainable (water limited) growth and yield of three sorghum genotypes differing in plant type and response to photoperiod for combinations of five sowing dates and three sites on the N-S climatic gradient in Mali, for the period from 1971 to 2004. The model used was SARRA-H equipped with the phenological model *Impatience*. Onset and end dates of the rainy season were estimated with the simple soil water balance model BIP. The resulting scenarios were evaluated on the basis of i) escape from drought, ii) escape of grain development phases from periods of high pest and disease pressure and iii) the resulting "safe" periods for sowing. The latter took into account the agronomic advantage associated with early sowing, observed by farmers to minimize weed competition and decreasing soil fertility during the wet season.

Environments. Three sites in Mali representative of different agro-climatic zones were studied, Nara (15°10' N, 7°17' E, 265 m asl; Sahel), Bamako (12°17' N, 7°57' E, 381 m asl; Sudan savannah) and Sikasso (11°21' N, 5°41' E, 375 asl; Guinea savannah). All sites have a hot, tropical climate with a mean, annual, maximal (minimal) daily temperature of 36.0 °C (21.7 °C) at Nara, 34.4°C (21.9 °C) at Bamako and 33.7 °C (21.0 °C) at Sikasso. Monthly patterns of temperature and potential evapotranspiration (PET) are presented in Table 1. All sites have a mono-modal pattern of rainfall with a distinct rainy season in summer, accounting on average for 394 mm at Nara, 885 mm at Bamako and 1099 mm at Sikasso.

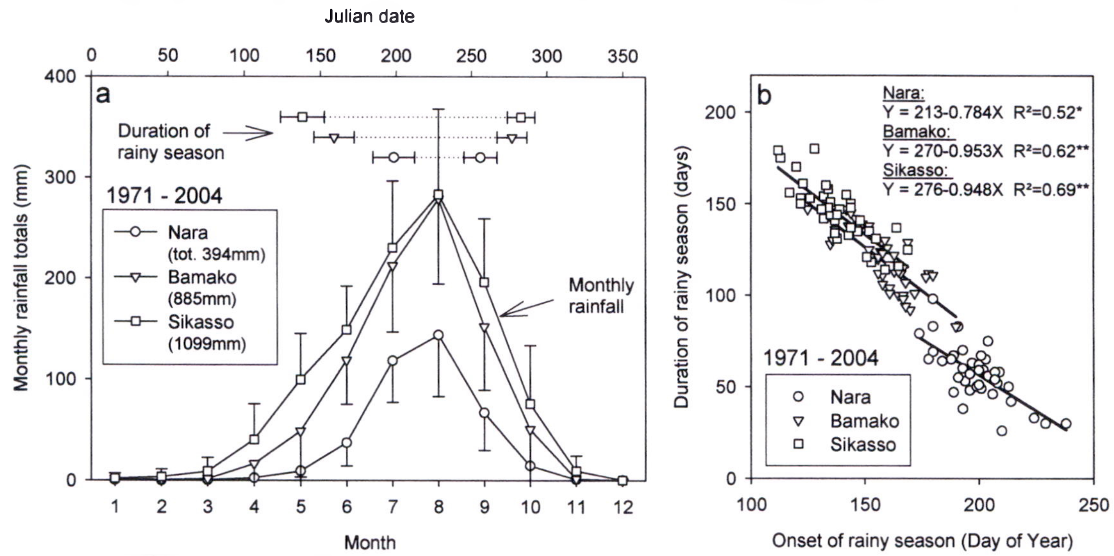

Fig. 1. Rainy season at Nara, Bamako and Sikasso for 1971-2004. a: Monthly rainfall (solid lines) and mean duration of rainy season ± s.d. (dotted). b: Duration of rainy season *vs*. its date of onset.

Genetic materials. Three well characterized (Kouressy et al., 2007) sorghum *(Sorghum bicolour* L.) genotypes were selected for this study to represent different plant types available to farmers in West Africa. V1 is a tall (up to 4.5 m), traditional, highly photoperiod-sensitive *Guinea* landrace from southern Mali with local name *Kendé Ngou*. V1 produces less than 2.0 Mg ha^{-1} grain but aboveground dry matter can exceed 20 Mg ha^{-1}. V2 is an improved dwarf cultivar (1.7 m) sharing 75% of V1's genome as well as its photoperiod sensitivity. It produces less biomass but more grain (up to 3.5 Mg ha^{-1}) than V1. Both V1 and V2 enable flexible cropping calendars because photoperiodic response makes flowering relatively independent from sowing date. V3 is a dwarf (1.7 m), early-maturing, photoperiod-insensitive, high-yielding (5.0 Mg ha^{-1}), *Caudatum* hybrid developed by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), coded ICSH89002. V3 must be sown at a specific date in order to synchronize flowering with the end of the wet season (to avoid drought, pest and disease problems during grain filling).

Results & conclusion. Simulation results indicated that potentially high yielding and photoperiod insensitive "modern" cultivars such as V3 have an advantage only in the north where the rainy season is short (Nara, Fig. 2). Sensitive response of flowering to photoperiod was essential for more humid environments having a long wet season, resulting in appropriate timing of flowering and greater flexibility of crop calendars. Traditional V1 was well suited to Bamako and Sikasso, improved V2 only to Bamako and the hybrid V3 only to Nara. These results are supported by experience from multi-location trials. In conclusion, the present methodology can be used to identify phenological and drought response traits required for specific agro-ecological zones, and to target existing genotypes to the most suitable environments.

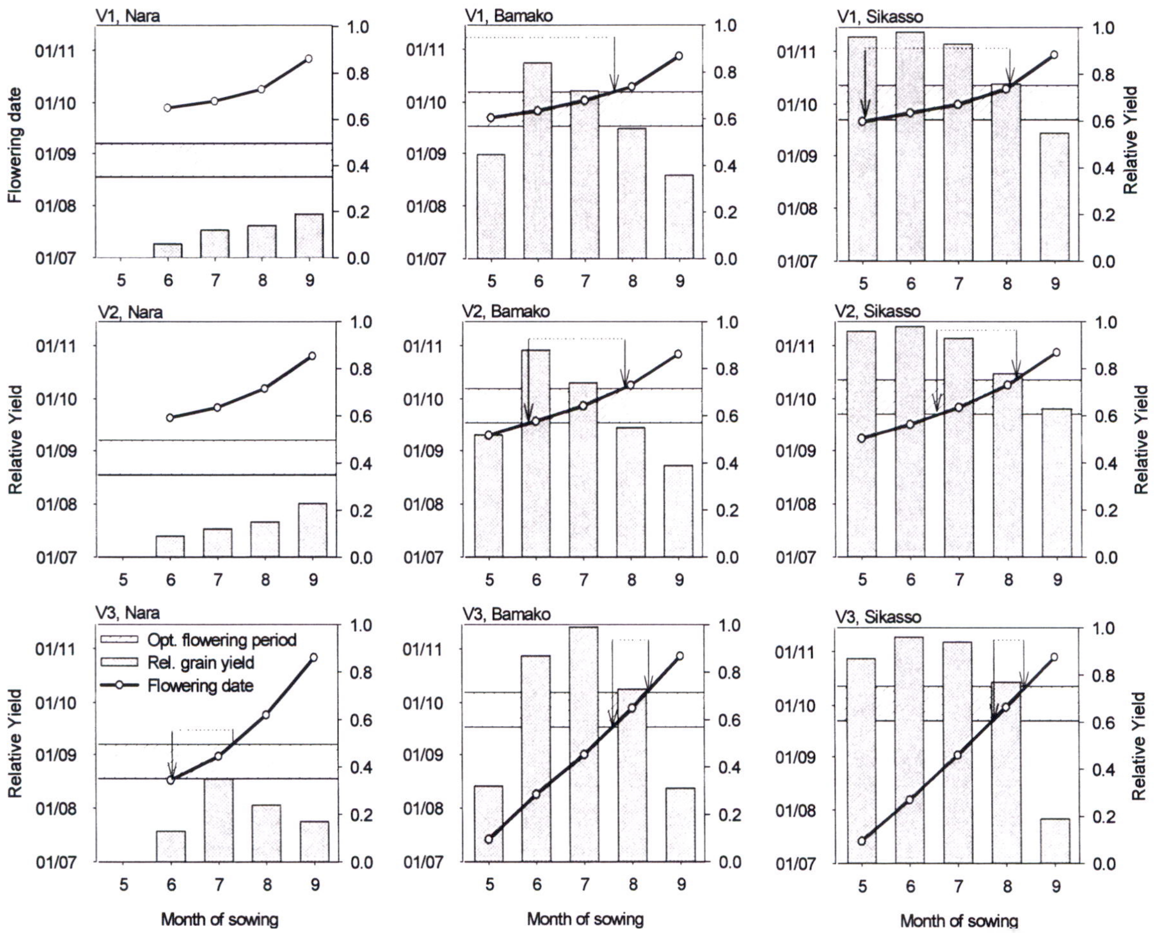

Fig. 2. Simulated date of flowering (circles and solid line) and relative, water limited over non-limited grain yield (vertical bars, refer to scale on right) for 5 sowing dates (01 May to 01 September), 3 sorghum cultivars (V1-V3) and 3 sites (Nara, Bamako and Sikasso). The horizontal bar indicates the optimal period for flowering (last 20 days before end of wet season) for avoidance of biotic stresses, resulting in a cultivar specific "window" for sowing date (marked by arrows).

Articles reporting these results:

Dingkuhn, M., Kouressy, M., Vaksmann, M., Clerget, B., Chantereau, J. 2007. Applying to sorghum photoperiodism the concept of threshold-lowering during prolonged appetence. *European Journal of Agronomy* **(in press).**

Kouressy M., M. Dingkuhn, M. Vaksmann, A. Clément-Vidal and J. Chantereau. 2007. Potential contribution of dwarf and leaf longevity traits to yield improvement in photoperiod sensitive sorghum. *European Journal of Agronomy* **(in press).**

Kouressy M, Dingkuhn M, Vaksmann M, Heinemann AB. 2007. Adaptation to diverse semi-arid environments of sorghum genotypes having different plant type and sensitivity to photoperiod. *Agricultural and Forest Meteorology* **(in press).**