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Sweet Fuel

Sweet Sorghum
an alternative energy Crop

Grant Agreement n° 227422

WP4
Deliverable 4.1:

Detailed information on phenotypic range and function of traits for stalk sweetness, photoperiod sensitivity, staygreen and grain yield for 12 contrasting genotypes

Composition of the consortium

CIRAD
ICRISAT
EMBRAPA
KWS
IFEU
UniBO
UCSC
ARC-GCI
UANL
WIP

This information was collected and exploited in the frame of the PhD of Sylvain Gutjahr:

Gutjahr S. 2012. Ecole Doctorale SIBAGHE : 'Analysis of useful morphogenetic and biochemical traits for developing dual-purpose (grain + bioethanol) sweet sorghums''. Thèse de doctorat soutenue le 5/7/2012. 118pp

Abstract

Sweet sorghum offers many advantages as an alternative to widely cultivated crops such as corn and sugarcane to produce biofuels: it is resistant to water stress, it requires few inputs; it has a shorter growth cycle compared to sugarcane in particular. Sorghum also exhibits a great genetic diversity and is genetically less complex than sugarcane. Finally, sorghum can be cultivated for dual-purpose uses, using grains for food or feed and sweet juice for biofuel production. Hence, sorghum is a promising option to reduce the competition for land and (water) resource use between food and fuel, in particular in cropping environments with high drought and heat stress frequency, as in West Africa. However, stem sweetness is a complex trait prone to genotype x environment interactions (G x E). The metabolic, morphological and phenological mechanisms involved in the kinetic of stem sugar accumulation and their possible competition with grain filling are largely unknown or controversial in the literature. The present work is part of the European project *Sweetfuel* and aims at better understanding these mechanisms and contributing to define dual-purpose sorghum ideotypes for soudano-sahelian conditions.

Based on field and greenhouse experiments respectively in Mali and France, it was found that sugars start accumulating in stem internodes at the onset of their elongation, i.e. potentially soon before the plant flowers. The successive accumulation of hexose and then sucrose in internodes could be dynamically explained by changes in the activity of key enzymes related to sucrose metabolism. In Mali, a field experiment performed on 14 genotypes, contrasted for photoperiod sensitivity and sown at three planting dates highlighted the interest of increasing vegetative phase duration to increase sugar yield. This was explained first of all by the higher number of internodes that could expand during a longer vegetative phase, and thus, by the higher production of stem biomass, and, to a minor extent, by the longer time for internodes to mature and accumulate sugar (sugar concentration in the stem was however fairly stable across sowing dates). Also, vegetative phase duration and photoperiod sensitivity can be considered as two key parameters promoting stem sugar content before grain filling. In the same time, it was shown that stem sugar content kept remarkably constant between anthesis and maturity in most of studied genotypes and that the reduction observed for some genotypes was overcome with an early sowing. Moreover, sugar accumulation in the stem between flowering and maturity did not ix

benefit from panicle pruning. These results together suggest that the competition for carbohydrates between stem sugar reserves and grain filling is weak; it is even weaker for big/large stem genotypes with huge sugar reserves in the stem that would buffer a post-flowering allocation of sugar from the stem to the grains if required. This low competition was confirmed at a finer scale, as no differences were observed in the activity of key enzymes of sucrose metabolism between the sterile and the fertile line of a same genotype.

This thesis was defended on 05th, July, 2013 at Montpellier and resulted in the publication of the following papers.

- Gutjahr S., Clément-Vidal A., Soutiras A., Sonderegger N., Braconnier S., Dingkuhn M., Luquet. D. -2013 - Grain, sugar and biomass accumulation in photoperiod-sensitive sorghums.II. Biochemical processes at internode level and interaction with phenology. Accepted in Functional Plant biology

- Gutjahr S., Vaksmann M., Dingkuhn M., Thera K., Trouche G., Braconnier S., Luquet. D. -2013 - Grain, sugar and biomass accumulation in tropical sorghums. I. Trade-offs and effects of phenological plasticity. Accepted in Functional Plant biology