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Sorghum as energy crop as an alternative to maize on dry production sites?

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1. Introduction, Knowledge, Objectives

Maize has a high biomass production and is used renewable energy source for methane production. An increase in temperature and a decrease in summer precipitation were predicted by the IPCC (Meehl et al. 2007).
The genus sorghum comprises species with a high potential for biomass production and large genetic variation in most physiological characteristics (Zeller 2000). Sorghum could be an alternative energy crop in the future due to its better drought tolerance (Singh and Singh 1995, Staggenborg et al. 2008). Energy plants should have a rapid youth development in spring, high water use efficiency in the summer and dry matter contents of approximately 28 % at harvest. The essentially limiting factor for sorghum production in the temperate zone is the vulnerability to low temperatures (Bacon et al. 1986, Tyriaki and Andrews 2001a). Low temperatures in spring lead to delayed emergence and an inadequate youth development. Cold periods in the summer result in a lack of maturation and dry matter contents below those needed for silage production.
The objective of the study was to analyse canopy growth and biomass production of different sorghum hybrids at two sites in Germany, to compare sorghum to a late maturing maize cultivar and to estimate the effect of row width on biomass production.

2. Material and Methods

Six sorghum hybrids (*Sorghum bicolor* x *bicolor* 'Maja', 'Wotan', 'Bulldozer', 'KSH8301', 'Zerberus' and *Sorghum bicolor* x *sudanense* 'Inka') and the maize cultivar 'Simao' (KWS Saat AG, Einbeck, Germany) were grown under field conditions at two sites (Hannover and Ruthe) in Lower Saxony, Germany. Plants were sown with a plant density of 20 plants m^{-2} under rain fed conditions in Ruthe (silty loam) in mid of May 2009 (291 mm precipitation from May to October) and end of May 2010 (298 mm). Plants were sown beginning of May 2010 in Hannover (408 mm, loamy sand). Planting densities were 20 plants m^{-2} for sorghum and 12 plants m^{-2} for maize in Hannover. At both sites, row distance was 0.40 and 0.67 m.
Canopy expansion was measured non-destructively with an optical method (LAI-2000 Licor, Lincoln, NE, USA) and leaf area index (LAI) was plotted as a function of thermal time assuming a base temperature of 9 °C. At the end of the growing season total dry biomass yield and dry matter percentage were determined. Statistical analyses were done with Tukey multiple comparison test.

3. Results

Temporal change in LAI (mean LAI over all sorghum hybrids and maize) was similar among the two production years in Ruthe when plotted against thermal time. Sorghum and maize needed approx. 380 °Cd to establish a LAI of 2. The initial increase of LAI started earlier for maize than for sorghum in both years. Canopy growth of sorghum was slightly delayed compared to maize. Sorghum grew faster in 2009 than 2010, which may be a result of low temperatures in late spring and low rainfall in early summer 2010. However, in late summer most of the sorghum cultivars showed higher LAIs than maize (Fig. 1). There was no consistent difference in LAI between the various sorghum hybrids and maize.

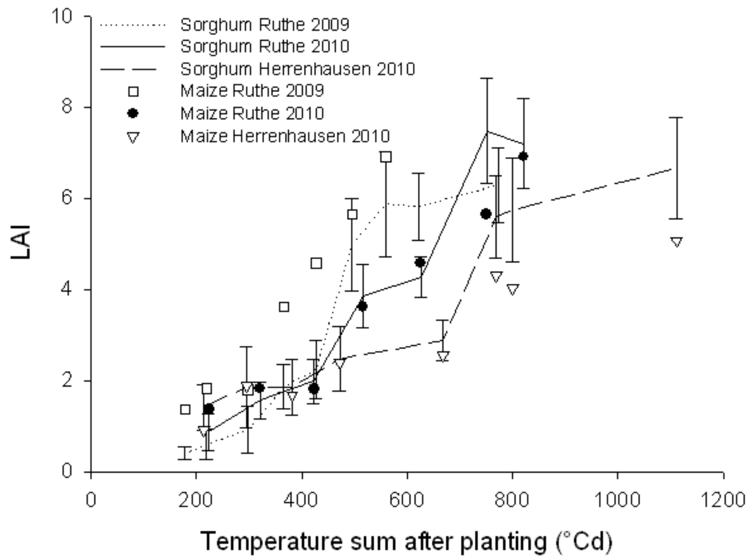

Figure 1: Temporal changes of mean leaf area index (LAI) averaged over all sorghum hybrids (means and standard deviations) and maize (mean) as function of thermal time at two production sites.

Dry matter percentage at final harvest ranged from 22.4 % to 30.8 % (2009) and 19.8 to 28.4 % (2010) for sorghum; maize reached 29.2 and 21.5 % in Ruthe, respectively. Probably due to late sowing, maize did not reach maturity in Ruthe in 2010. In Hannover dry matter percentage was between 21.8 % ('Bulldozer') and 28.8 % ('Maja') for sorghum. Maize had a dry matter content of 30.7 %. There was a similar ranking of the sorghum cultivars across the two production sites. Only two sorghum hybrids ('Maja' and 'Wotan') reached a dry matter content about 28 % and were able to keep up with maize (Fig. 2). Leaf weight ratio (leaf mass of total plant dry mass) was 0.15 for maize, and ranged for sorghum hybrids between 0.21 and 0.30. Differences in dry matter percentage among sorghum cultivars was negatively related to leaf weight ratio (r^2 = 0.86, data not shown).
Final dry matter averaged over all plant types was similar in both years in Ruthe. Dry matter ranged between 1.85 and 2.7 kg m^{-2} at final harvest, maize had 2.3 kg m^{-2} and 2.12 kg m^{-2}, in 2009 and 2010. The highest dry matter was found for 'Inka', the lowest for 'Bulldozer' in 2009 and 2010 in Ruthe. On the sandy soil in hannover, dry matter yield was

clearly lower than in Ruthe. It ranged between 1.22 and 1.97 kg m^{-2}. 'Inka' showed the lowest dry matter yield (Fig. 2). There was no clear difference in dry matter yield between maize and the other five sorghum hybrids. However, 'Inka' produced more dry biomass in Ruthe than in Hannover ($p < 0.05$).

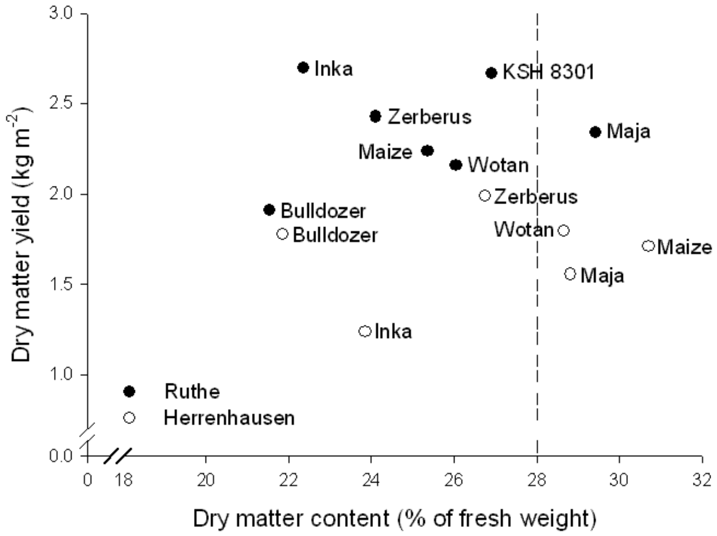

Figure 2: Dry matter yield (kg m^{-2}) and dry matter content for sorghum hybrids and maize in Ruthe and Herrenhausen (Lower Saxony, Germany).

Total dry biomass of sorghum cultivars was equal or 20 to 40 % higher compared to maize when grow at 40 cm row distance. At 67 cm in Ruthe dry matter yield was approximately 10 % less compared to maize. Under favourable soil conditions sorghum genotypes had higher yields at smaller row distances. In Hannover a wider row distance lead to more total dry biomass in comparison to maize. However, the effect of row distance on dry weight production was not significant on both sites (Tab. 1).

Table 1: Relative dry matter yield at final harvest of different sorghum hybrids cultivated in row distances of 40 and 67 cm compared to maize (dry matter yield = 1) at two production sites 2010. Shown are means and standard deviations.

Location	Row width	'Maja'	'Inka'	'Wotan'	'KSH 8301'	'Zerberus'	'Bulldozer'	Maize
Ruthe	0.40 m	1.2 ±0.3	1.4 ±0.5	1.1 ±0.3	1.4 ±0.4	1.3 ±0.5	1 ±0.3	1
	0.67 m	1 ±0.2	1.1 ±0.2	0.9 ±0.2	0.9 ±0.1	0.9 ±0.2	0.8 ±0.2	1
Herrenhausen	0.40 m	0.8 ±0.1	0.7 ±0.2	1 ±0.1		1 ±0.2	1 ±0.02	1
	0.67 m	1 ±0.2	0.8 ± 0.1	1.1 ±0.1		1.3 ±0.3	1.1 ±0.2	1

4. Discussion

Differences in developmental stages between sorghum hybrids and lines were also observed by Gaudchau and Honermeier (2009). In the study sorghum genotypes differed between time point from sowing to show the flag leaf and dry matte percentage. The negatively relation between leaf weight ratio and dry matter percentage was found by Manderscheid et al. (2010). Different dry matter yield levels on sandy and heavy soils and genotype x environment interactions as observed in the present study were also found by Gaudchau and Honermeier (2009).

5. Conclusions

The present study showed that canopy growth of sorghum in comparison to maize was slightly delayed in early summer, but in late summer sorghum showed a higher LAI than maize. At least three sorghum cultivars had similar biomass yields as maize. Dry matter percentage was different among sorghum genotypes and only two cultivars kept up with maize. Some sorghum hybrids are an alternative to maize on dry production sites.

6. Literature

Bacon RK, Cantrell RP, Axtell JD (1986): Selection for seedling cold tolerance in grain-sorghum. Crop Sci. (26), pp. 900-903.

Gaudchau M and Honermeier B (2009): Untersuchung verschiedener Sorghumsorten und- stämme für die Biogasproduktion. In: Märländer B, O. Christen, A. Düker, C. Kenter, S. V. Tiedemann, Gesellschaft für Pflanzenbauwissenschaften, Hrsg., 53. Jahrestagung der Gesellschaft für Pflanzenwissenschaften, Mitteilungen der Gesellschaft für Pflanzenwissenschaften (21), pp. 69-70; ISSN 0934-5116 [Poster] [Koexistenz Grüne Gentechnik, Hohenheim, Deutschland, 28. - 30. September 2010]

Manderscheid R, Duensing R, Erbs M, Fritz M, Hartmann A, Stützel H, Uptmoor R, Weigel HJ (2010): Investigation of canopy development and biomass production of different sorghum-genotypes as compared to maize. In: Wery, J., I. Shili-Touzi, A. Perrin (Eds.), Proc. XI ESA Congress, pp. 497-498; ISBN: 978-2-909613-01-7 [Poster] [Agro2010, Montpellier, FRANCE, AUG 29 - SEP 3]

Meehl GA, Stocker TF, Collins WD, Friedlingstein P, Gaye AT, Gregory JM, Kitoh A, Knutti R, Murphy JM, Noda, A, Raper S C B, Watterson IG, Weaver A J and Zhao Z-C (2007): Global Climate Projections. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (Eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Annual Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 747-845.

Singh BR and Singh DP (1995): Agronomic and Physiological-Responses of Sorghum, Maize and Pearl-Millet to Irrigation. Field Crops Res. (42 (2-3)), pp. 57-67.

Staggenborg SA, Dhuyvetter KC and Gordon WB (2008): Grain sorghum and corn comparisons: Yield, economoic and environmantal responses, Agronomy Journal (100), pp. 1600-1604.

Tiryaki I and Andrews DJ (2001a): Germination and seedling cold tolerance in sorghum: I. Evaluation of rapid screening methods. Agronomy Journal (93), pp. 1386-1391.

Zeller FJ (2000): Sorghumhirse (Sorghum bicolor Moench L.): Nutzung, Genetik, Züchtung; Die Bodenkultur (51), pp. 71- 85.