

Sorghum, an innovative crop for middle & Nordic regions of Europe and from 58° NL to 55° SL

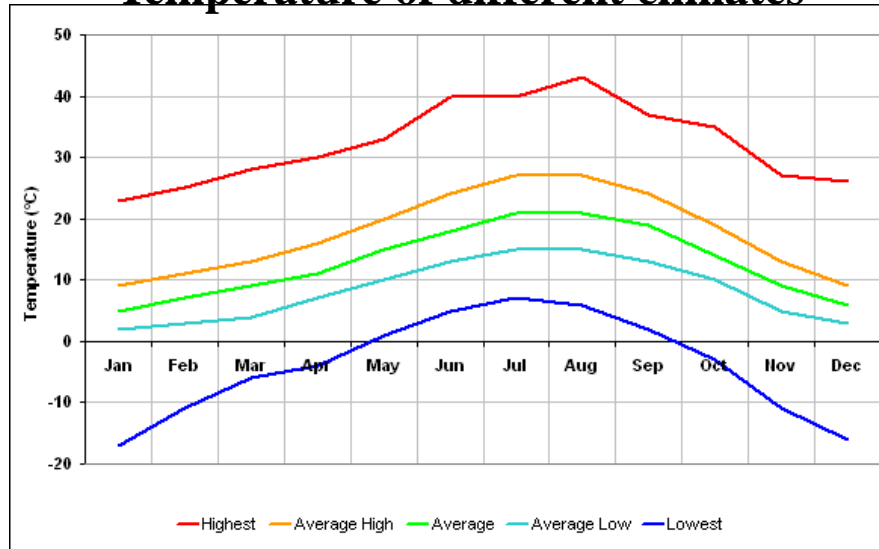
Dr Ir Walter A.J. de Milliano

Sorghum in the Northern hemisphere



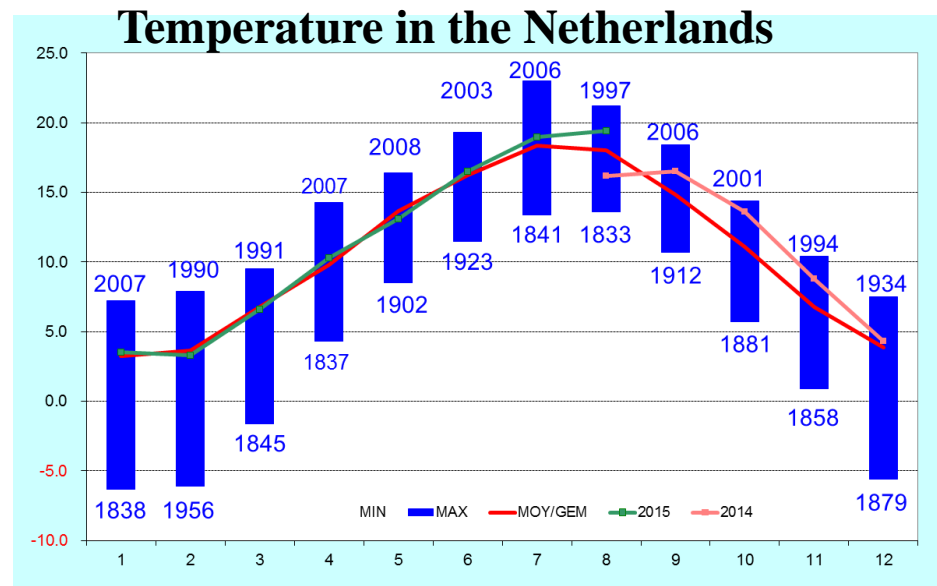
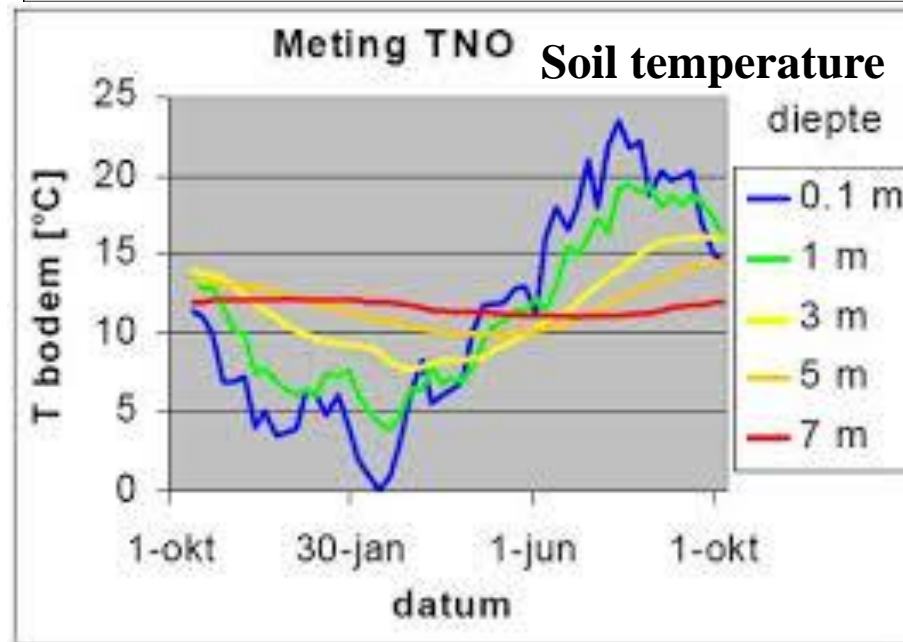
Environment - Temperature

Temperature of different climates



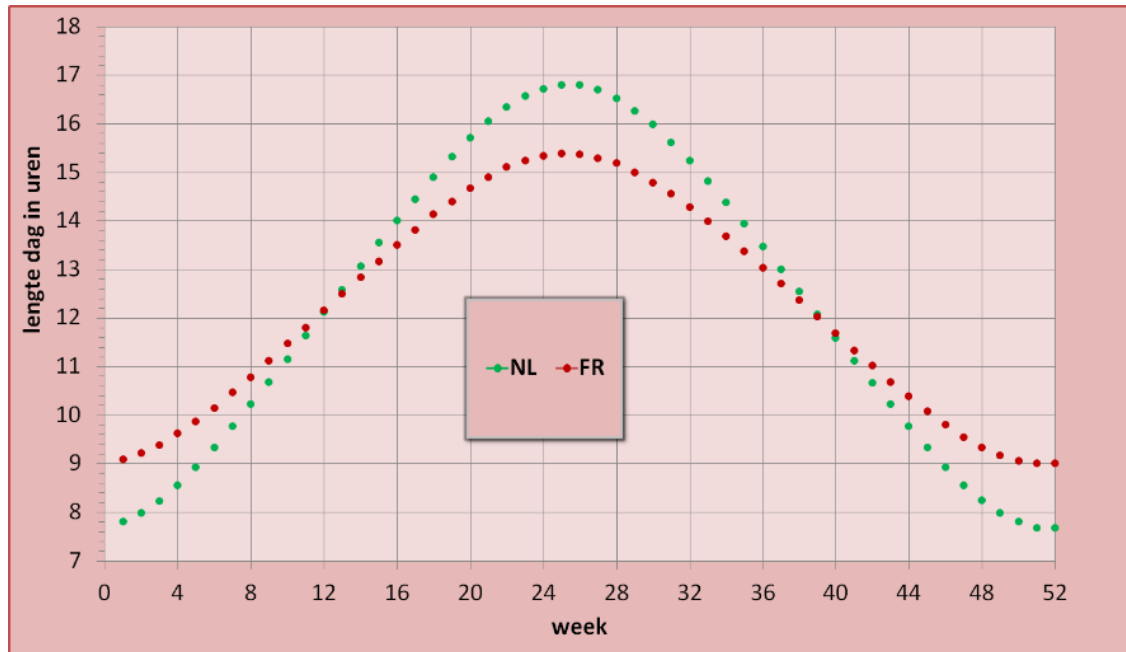
Sorghum has been domesticated and selected, mainly between the tropics. Consequently it requires warmth and a short day.

Climates at higher latitudes (temperate) have cold soils at sowing and cool weather from flowering onwards



Temperate climate

Long Day



Short day is a requirement of sorghum to become generative.
During the short day in NL (December-January), it is cold.
During the warmer summer period the day length is >16 h.
The higher the latitude, the longer the day length

Sorghum at Hoeve Dierkensteen

14 September 2015



Sorghum for a Temperate climate



To obtain valuable sorghum one requires:

- **Earliness and adaptation to local (NOT short) day length**
- **Adaptation to cool weather, in particular at emergence and in period from flowering,**
- **Good diverse genetics**

Performance of BTx623 sorghum and late hybrids at Hoeve Dierkensteen (NL), 14 September 2015



Sorghums sown 15 May

BTx623 in center is not able to make a full stand (cold).

This is even more important for sorghum sown earlier

Performance of Lubbock (Tx) Cold tolerant sorghum at Hoeve Dierkensteen (NL), 14 September 2015



Sorghums sown 7 May (right, 2 m plot length) but also 1 June 2015 (left) are, AT BEST, heading. Too late for HD conditions. NOTE: Day length governs generative earliness!

Progress Sorghum breeding

Sorghum Hoeve Dierkensteen NL 2013



Sorghum cold tolerance at the generative stage



Tillering, Main stem with white grain, second tillers taller, green grain, third tillers even taller and least far developed



Sterility

Performance of sorghums sown 7 May 2015, at Hoeve Dierkensteen (NL), on 14 Sep 2015



Local Semi-open and Compact headed hybrid sorghum
grain types are beginning seed coloring.

Steps made in Sorghum breeding

- ▶ 2005-2008 NL - Selection at HD in the Netherlands(NL) for viable grain production
- ▶ 2008 NL - Crossing of best selections, hand pollination
- ▶ 2008 South Africa (SA) - F1- **Selection**
- ▶ 2009 - F2 - NL and F3 - SA (inbreeding by natural selfing)
- ▶ 2010 - F2 - F4 NL and F5 - SA
- ▶ 2011 - F3 - F6 NL and F7 - SA
- ▶ 2012 and 2015 -Testing of F3 onwards - NL
 - Multi-locational Tests of F7 - Results see progress
- ▶ 2014-2022 - First breeding and selection for Denmark
- ▶ 2021 - First varieties registered on European Variety List
 - ▶ Dusormil HD7 with colored grain
 - ▶ Dusormil HD19 with white grain



Dusormil HD19



Dusormil HD7

Progress Sorghum breeding NL 2021

Dusormil HD7



Dusormil HD19



Dusormil HD100



Products from Dutch sorghum grain




Progress in Sorghum breeding in Denmark

- First Contact 2011
- First trial with Dutch bred sorghums in 2012
- 7&8 November 2018
Poster with results
2nd European
Sorghum Conference,
Milan, Italy

Sorghum trials Roskilde,
26 September 2022

UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE
Department of Plant and Environmental Sciences
Plant and Soil Science Section



Sorghum adapted to Northern European temperate climate, 55° latitude

Søren K. Rasmussen, Molecular Plant Breeding, University of Copenhagen, Frederiksberg, Denmark
Email: skr@plen.ku.dk

Introduction

Sweet sorghum as **dual purpose crop** for biofuel production and feed is attractive due to the fact that it is productive also under reduced-input agriculture. However, it needs to be adapted to the cool climate of North Europe. Several germplasm collection have since 2010 been grown in Denmark and compared to **contrasting climates**.

Field evaluation 2017







Five lines were grown as single rows at two locations. Data for stem **protein, sugars and fructans** are shown.

2017	Protein	Sucrose	Fructose	Glucose	Total free	Fructan
Line	g/100 g DM	g/100 g DM	g/100 g DM	g/100 g DM	g/100 g DM	g/100 g DM
CN1	5.2	7.0	1.0	1.1	9.1	nil
CN1-BI	4.5	12.0	2.7	3.8	18.5	0.8
HD12	5.8	11.3	2.0	1.2	14.5	nil
HD19	6.4	11.3	1.7	2.0	14.1	2.3
CN2	5.3	18.1	2.6	5.4	22.6	7.3

Yield trial 2018 (55°40' N and 12°18' E, Taastrup, Denmark)

Six contrasting Dutch lines (no. 1-6) were grown in RCBD with 4 replicates, each plot 3 rows (10m). Sown in May and harvested October 15, 2018. In spite of abnormal long, **dry and hot summer**, these sorghum lines all performed well and **produced seeds**.

2018	Line	Heading	Brix-value	PHT	Biomass wet	Biomass dry
No.	2018	Date	(g sugar / 100 mL)	cm	g/10 plants	g/10 plants
1	HD7	July 19	7.0	157	3092	552
2	CN1		8.6	135	1891	420
3	S4		7.5	140	1809	405
4	CN6	July 25	8.0	156	3355	622
5	HD19		6.7	146	3131	599
6	CF		8.9	140	2110	470

Fact box 1

A **mapping population** of Chinese sorghum was grown in Denmark and China and morphological, biomass and biofuel traits were found with high broad-sense heritability. Using DNA markers significant QTLs were discovered and it was concluded that sweet sorghum with tall plant, fast maturation and high stem Brix content can be bred as a biofuel crop for high altitude climate (Theor Appl Genet 2015).

Fact box 2

A collection of accession from ICRISAT was grown in 2014 and 2015 in Denmark and some lines could accumulate **high amount of sugar** in the stem juice. (Int J Res Agric Forest. 2018). The yield stability and bioenergy potential were also compared between the contrasting temperate and tropical climates of Nigeria (Can J Agric Sci, 2018).



First germination from seed to seed, in Denmark

23 August 2017



**55° 65' NB,
12° 30' OB,
16 m a.s.l**

22 June 2018



Progress Sorghum breeding Denmark

First on farm trial 2021



Strong points Sorghum

1. **C4 crops have a more efficient** C-fixation than our well adapted C3-crops e.g. barley, wheat, etc.
2. **Multipurpose crop for:**
 1. New food products
 2. Building material
 3. Ornamentals
 4. Fodder,
 5. Water
 6. Sugar,
 7. Wax,
 8. Fibres
 9. Dhuririn
 10. Phenols,
 11. Energy from cell
 12. Crop rotation
 13. Efficient water use (many physiological adaptations, e.g. growth stop during stress stay green and regrowth after stress)
 14. Efficient N-use
 15. Reduction of N₂O, root exudates stimulate microorganisms
 16. Soil improvement with fine root system
 17. New addition for wild life to eat and hide
 18. Resistance to Pests and Diseases
 1. Resistance Maize Root Borer (*Diabrotica virgifera*),
 2. Resistance to certain **Fusarium species** forming mycotoxins
 3. Resistance to **Rhizoctonia sp.**



Conclusions



- 1. There is a new multipurpose crop Sorghum**
- 2. It gives new opportunities to support the circular economy**
- 3. It deserves more attention from Swedish research to develop so that new products and opportunities can be realised**
- 4. Sorghum will produce seeds in southern regions but biomass production may be more economic**
- 5. It requires practical knowledge to produce and experience helps**
- 6. It may provide an opportunity for collaborations between agriculture and the building sector and thus reduce the requirement to cut trees**

Thank You For this Opportunity to be with you



Thanks are due:

- ▶ to PlantLink Organizing Committee to make this meeting possible
- ▶ all those that helped with research to introduce sorghum in the Nordic parts of Europe. In particular:
 - ✓ Prof. E. Alexandersson and Kibrom B. Abreha
 - ✓ Prof. S. Rasmussen and students
 - ✓ Prof. S.E. Jacobsen and team
 - ✓ Prof. M. Laing of ACCI to provide the opportunity to work with sorghum



Progress in Sorghum breeding at Hoeve Dierkensteen, NL

- ▶ Plant height between 1,5 up to 2,9 m
- ▶ Heads per plant - between 1 and 8 (tillering)
- ▶ Stem thickness between 0,6 and 1,3 cm
- ▶ Fresh plant weights of 20 to 100 mt/ha
- ▶ VCOS T&T was up to 74%
- ▶ At full maturity, sweet stem
 - ▶ Brix for sugar in dry matter of up to 27%
- ▶ There are tan and no tan plant selections in F7+
- ▶ Heterosis occurs
- ▶ Hybrid experience with *S. bicolor*, *S. nigricans* and *S. sudanensis*

Taastrup DK Malmö SW



Optimal average	12	13	17	19	19	16	14		84	98	110
Location	Apr	May	June	July	August	Sep	Oct	Nov	May-Sep	May- Oct	Apr-Sep
Malmö SW min Temp °C	12	18	21	23	22	18	13	8	102	115	127
Malmö SW max	4	8	11	14	13	11	7	4	57	64	68
Malmö SW avg	8,0	13,0	16,0	18,5	17,5	14,5	10,0	6,0	80	96	98
Optimal average	12	13	17	19	19	16	14		84	98	110
Location	Apr	May	June	July	August	Sep	Oct	Nov	May-Sep	May Oct	Apr-Sep
Taastrup DK min Temp °C	11	15	18	22	21	17	12	7	93	105	116
Taastrup DK max	5	8	13	14	14	12	8	5	61	69	74
Taastrup DK avg	8,0	11,5	15,5	18,0	17,5	14,5	10,0	6,0	77	93	95