Challenges and genetic gains on forage sorghum for areas above 48º latitude

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LIMITATIONS AND BREEDING CHALLENGES FOR FORAGE SORGHUM ABOVE 48º LATITUDE

New Genetics for forage Sorghum for Europe were required – adaptation very rare

- Cool temperatures at long day - Plants remain vegetative, or have late flowering and ripening
  - At sowing – No or poor emergence
    > Multiple emergences and tillering cause variation in ripening
  - At and after flowering – No or poor
    - Pollen fertility
    - Grain formation
    - Grain filling
    - Germination
- Poor young plant vigor - Poor and late soil cover, poor competition with weeds
- Lodging - Complicates harvest and reduces forage yield and quality
- Moist conditions at harvest - Affects grain quality negatively
- Improvement of other key traits - Forage quality traits including grain quality

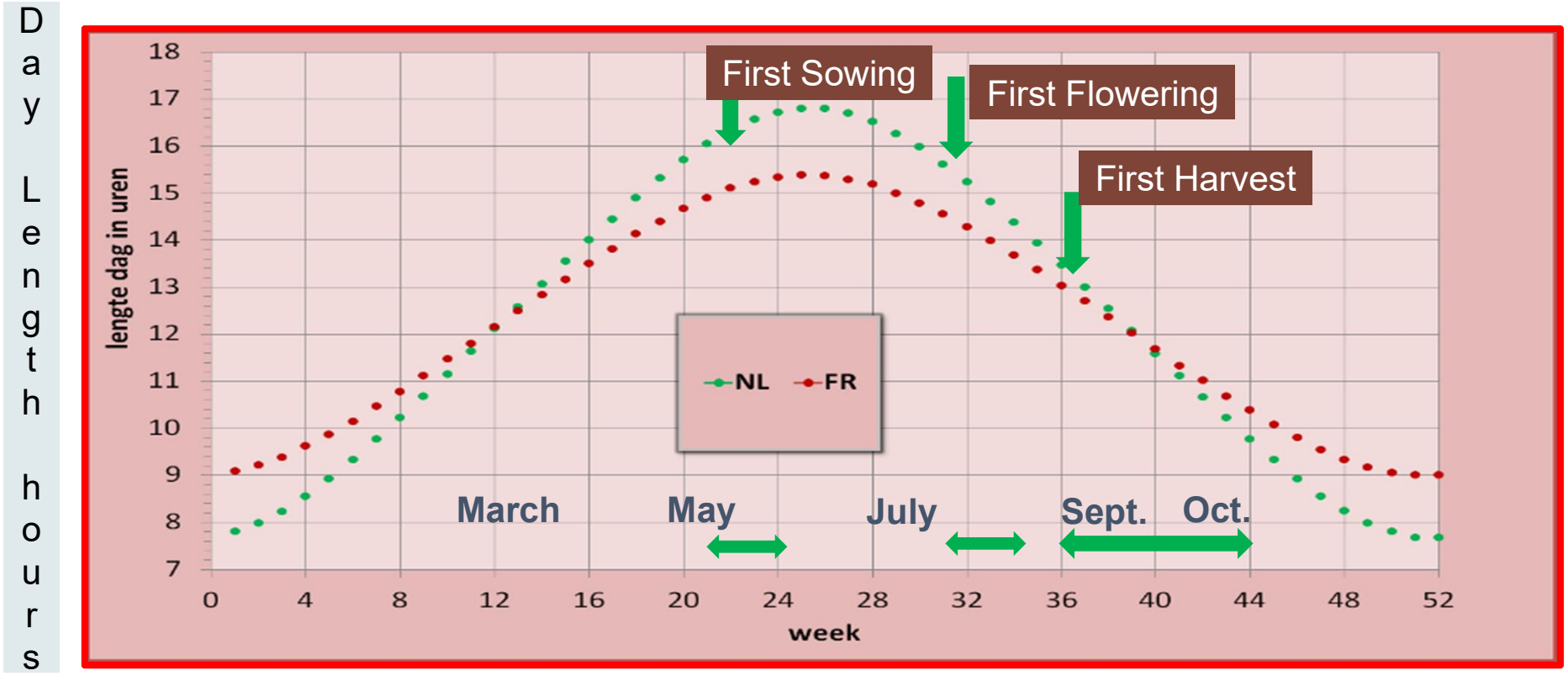
High Latitude Location for Sorghum Breeding
Farm (Hoeve) Dierkensteen (HD), The Netherlands (NL)

Area above 48º latitude

Oostburg
51° 20' NL, 3° 30' EL
1 m a.s.l.

Milan
45° 27' NL, 9° 11' EL

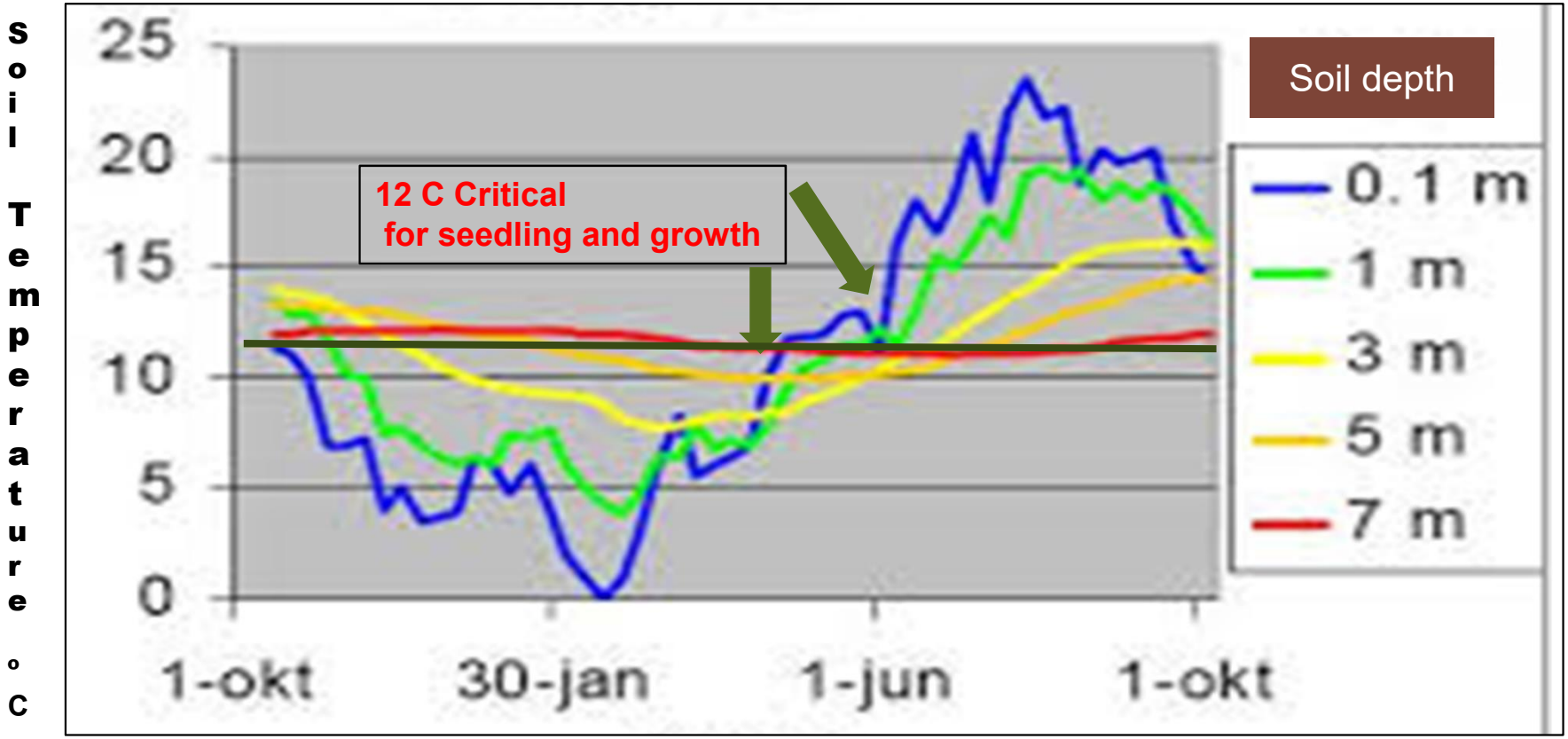
Areas in the Netherlands are above 48º Latitude and have a Temperate Climate with a Long Day, only during summer



At a day length between 16 and 17 hours, Temperature and genetics determine whether:
Sorghum becomes generative and produces viable seed
and whether possible Short Day requirements are fully off-set (Hypothesis)

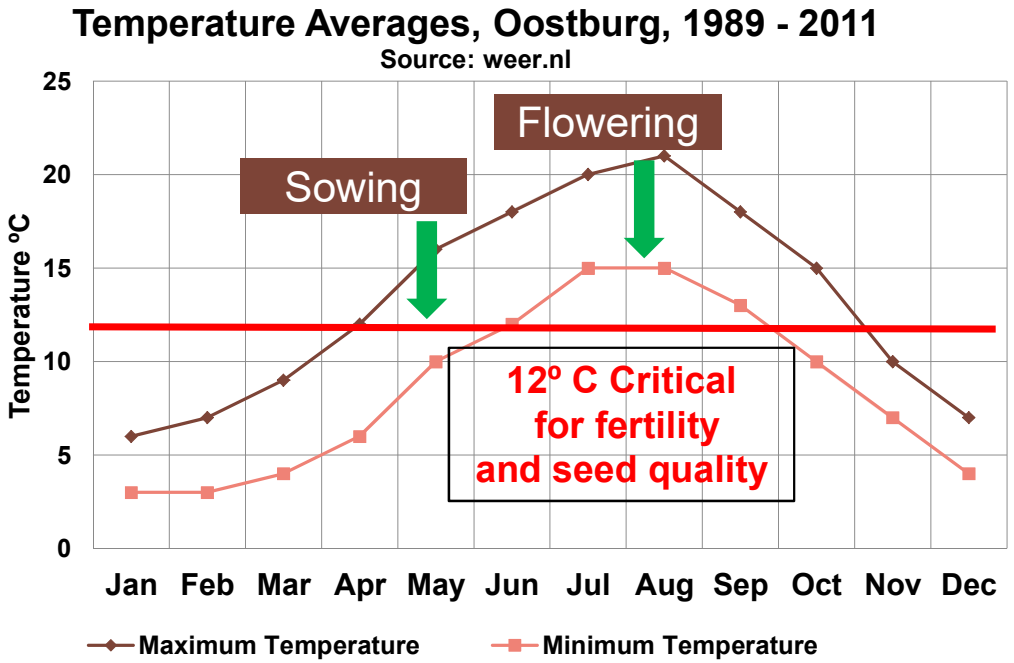
(Purseglove, J.W. 1972, Tropical Crops. Monocotyledons, p.270)

Near Critical Soil Temperature for Emergence in Areas above 48º Latitude

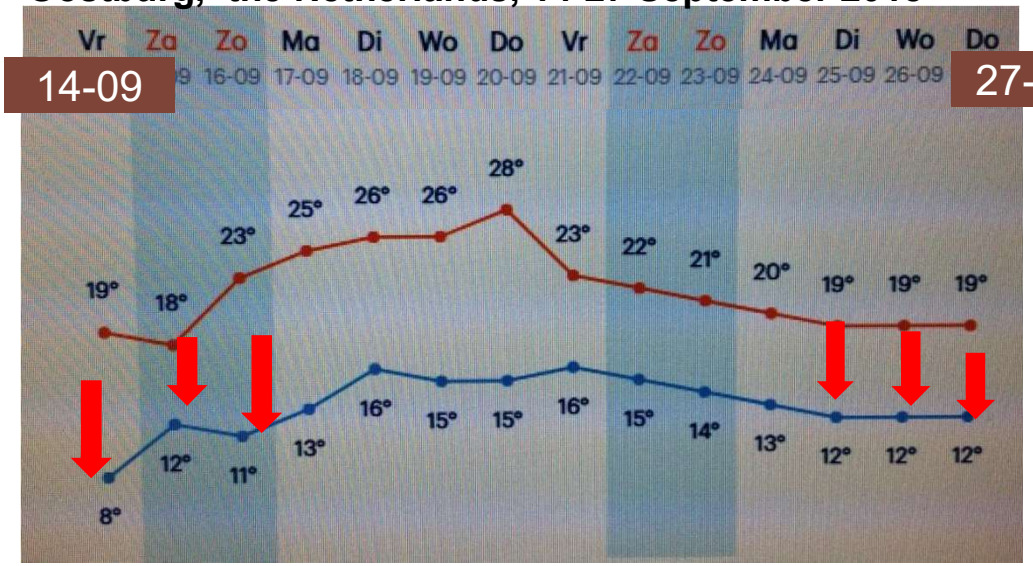


Before and after emergence, Temperate and **Land Climate,** may have below critical temperatures of **12º C in soil and air**

Air Temperature for Growth and Seed set, in Areas above 48º Latitude



Even in Warm period several cold nights
Oostburg, the Netherlands, 14-27 September 2018



Temperate areas above 48º Latitude have:

- Relatively Cool seasonal temperatures – average below 21º C
  - Slowing down growth / in particular of young plant
- Below critical night temperatures from flowering onwards,

resulting in: Poor seed set and
Variable quality of seed

Sorghum breeding scenario at Hoeve Dierkensteen, NL

- 2005-2008 NL – Very Few Southern African Inbred restorer lines show some viable grain in NL
- 2008 – 1st Crossing in NL of best selections (**sweet stem x grain type**), hand pollination
- 2008/09 - F1 hybrid planted in counter season (CS)
- 2009 - F2 sown in NL, Inbreeding with open pollination and selection
- 2009/10 - F3 produced in CS
- 2010 - F2 - F4 planted in NL - and F5 in CS - open pollination
- 2011 - F3 - F6 planted in NL and F7 in CS- open pollination
- 2012 and 2015 -Testing of F3 onwards in NL – **with selfing**
  - Multilocational Tests of F7 – Indicative Results see table next slide
- Since 2014 - First hybrids made with commercial and public female lines
- Since 2015 - 1 ha tests on different soils
- 2018 - Start of Variety registration for areas above 48º NL
  – under French expertise in Southern France

Sorghum at Hoeve Dierkensteen
14 September 2015

Sorghums Developed at Hoeve Dierkensteen

Viable Seed set in Denmark

with assistance of Prof. Søren K. Rasmussen

55° 65’ NL, 12° 30’ EL, 16 m a.s.l.

Explorative Yield & feed value Sorghums and Maize

After N. van Eekeren – Louis Bolk, V-Focus, 2014: 16,17

Nr				
S1	Piper	Sorgum bicolor x Sudanese		SC 1= Seed Company 1 American Genetic
S2	Sole	Sorgum bicolor x Sudanese	Early	SC 2, KWS
S3	Bovilal	Sorgum bicolor x Sudanese	Early	SC 3, Saaten Union
S4	Sweet California	Sorghum bicolor		SC4= Barenburg
S5	Zerberus	Sorghum bicolor	Medium early	SC2
S6	L3	Line	Early grain	Walter de Miliano
S7	L7	Line	Early grain	Walter de Miliano
S9	L11	Line	Biomass late	Walter de Miliano
Maize	Messago	Zea mais		

Explorative data 2013	tons dry matter/ha	Starch	Sugars	Starch + Sugars	Raw Protein	Raw cell material	Raw ash	Raw fat	VCOS	VCOS T&T	Phosphorus
Piper	9	89	97	186	118	273	54	23	66	60	3
Sole	15	212	64	276	93	243	41	25	66	60	2,1
Bovilal	9	163	100	263	98	239	47	21	69	63	2,3
Sweet California	13	98	233	331	91	210	52	16	81	79	2,6
Zeberus	17	35	190	225	85	302	51	11	71	64	2
L3	13	186	120	306	84	238	51	17	71	68	2,1
L7	18	264	113	377	95	168	48	23	75	72	2,3
L11	12	170	141	311	105	238	48	17	72	69	2,5
Messago	20	251	84	335	70	227	34	20	74		1,9

Favorable values for Sorghum compared to Maize

Cold tolerance does not secure seed set above 48º latitude

None of the cold tolerant sorghums from Lubbock (Tx) had viable seed viable set at 51º NL, not even supposedly day length neutral widely adapted sorghums like Macia (far left), neither when sown 7 May (right 2m plot) or 1 June (left 2 m)

Progress in Sorghum breeding at Hoeve Dierkensteen, NL

Achievements of our breeding program	What remains to be improved
Plant height was between 1,5 up to 2,9 m	– Tall plants are late and show lodging susceptibility
Heads per plant - between 1 and 8	– Tillers gives unequal ripening and plant height difference
Stem thickness was between 0,6 and 1,3 cm	– Thick stem (> 1,5 cm) was rare
Fresh plant weights of 40 to 100 mt/ha	– High Biomass was associated with late and lodging
VCOS T&T was up to 72%	– High digestion was associated with high sugar and high starch

At full maturity, sweet stem

- Brix for sugar in dry matter of up to 27%, reduced by seed set

Sorghum research

Sorghum Counter Season or Off-season

- ACCI, University of KwaZulu-Natal – South Africa
- African Seed Company - Sierra Leone
- University of Denmark

Cold tolerance and adaptation to long day

- USDA, Sorghum Cold Tolerant Research - USA
- University of Denmark

Research Northern Europe

- Louis Bolk – Netherlands and ILVO Belgium - Sorghum as a fodder crop
- Wageningen University and Research –Fodder quality by soil type and science quality testing
- Rusthoeve – Netherlands – Sorghum agronomy and networking for economic use of sorghum products
- University of Denmark – agronomy - quality
- Others – commercial options

Required

- Research on seedling vigor and cold tolerance (frost tolerance, earlier sowing)
- Facilitation for introduction of a new crop
  - Publicity – Crop and products not known to legislation, farmers and few consumers
  - European and Local regulations

3rd European Sorghum Conference in Rotterdam, The Netherlands

Summary of Progress with Sorghum breeding at Hoeve Dierkensteen, NL

Within one or more crossing generations over a period of 10 years :

Viable grain of different colors was produced from 51º NL up to 55º NL

- White, red, colored and 'black'
  - Attention is required for grain mold in white grain

A Dry Matter Biomass production of up to 18 mt per ha and higher in hybrids and tall lines

- Levels of Protein in forage of (8 to 11%) and Sugars (11 to 14%)
- Crude Protein of grain of up to 14%

Grain yields varied between entries: 1 to 7,5 mt/ha

Lines produced 6 to 7 mt/ha of grain in Chili in 2015