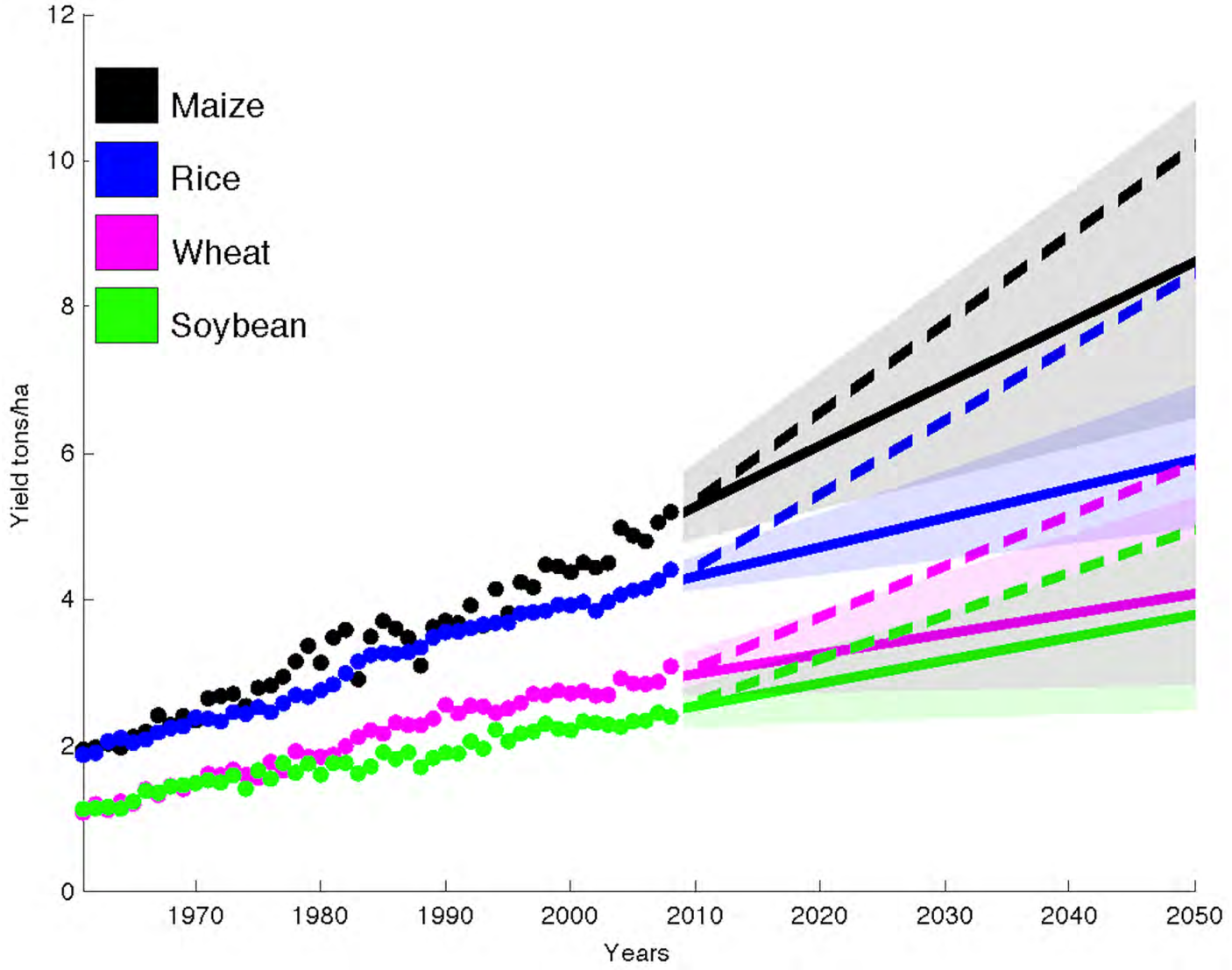
Daylength effects on growth and seed production efficiency in bambara groundnut (*Vigna subterranea* L.)

Presidor Kendabie[1], Soren T. Jorgensen[2], Festo Massawe[3], Sayed Azam-Ali[4] and Sean Mayes[1,4]

Content

- Background and justification
- Photoperiod control in bambara groundnut
- Genetic crossing in bambara groundnut
- Development of breeding materials
- General conclusions and implications

Global crop yield projections



Ray *et al.*, (2013) *PLoS ONE 8(6)*

Complementary approach to boost productivity

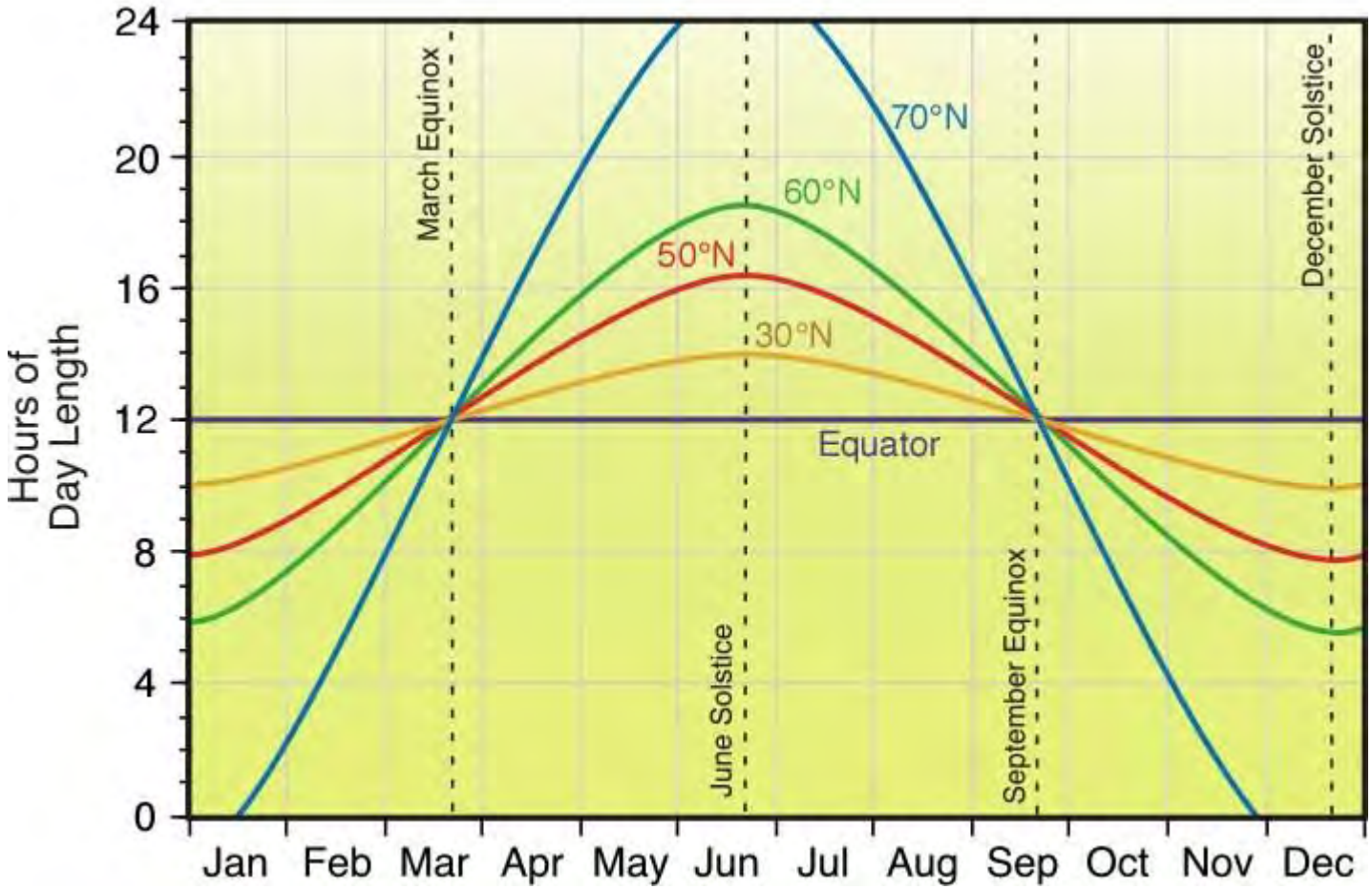
One approach is to revisit minor crops: Farming systems in the tropics, a rich food, nutritional and cultural history for the poor resource-base farmers in sub-Saharan Africa.

Bambara groundnut (*Vigna subterranea* L.):

- **Native African legume**
- **Rich in protein**
- **Able to fix nitrogen**
- **Highly drought tolerant**
- **Disease resistant**
- **Short-day crop with a unique photoperiod**

Photoperiod control in bambara groundnut

Flowering, Fruit-set, fruit-filling and maturity are all under the control of photoperiod.



Annual variations in day length for locations at the equator, 30, 50, 60, and 70° North latitude.

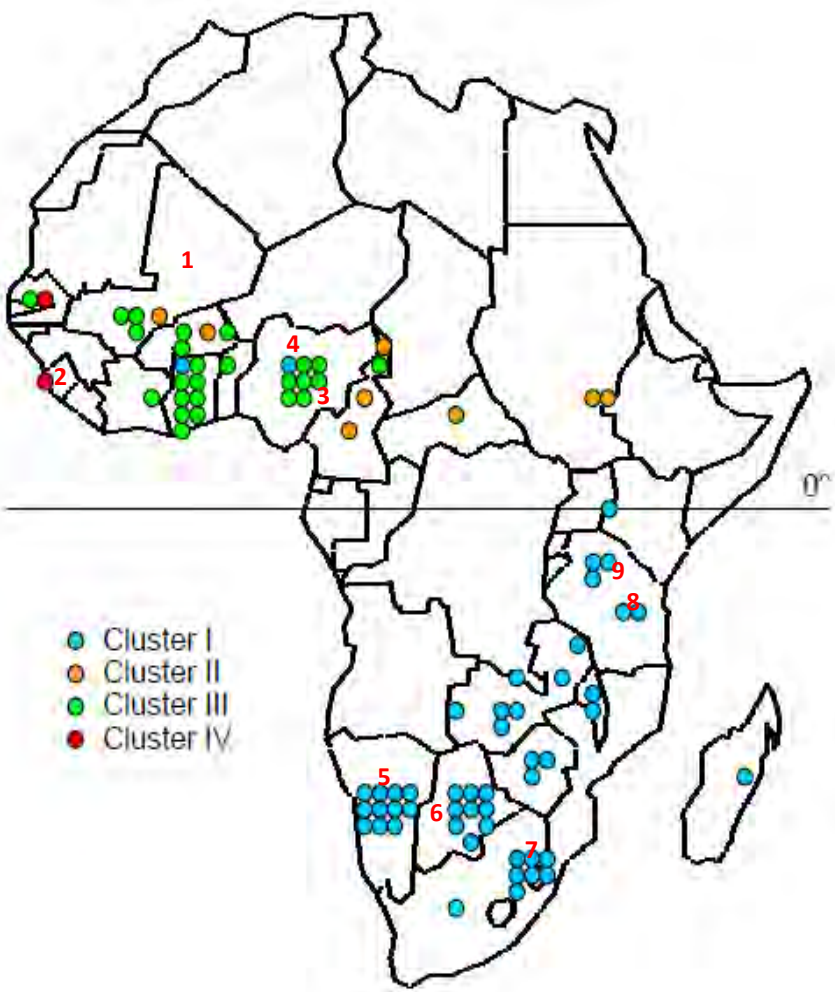
Pidwirny, M. (2006). *Fundamentals of Physical Geography, 2nd Edition*

Aim and objectives

The aim of this study is to unlock the genetic potential of this important tropical legume. Specific objectives include:

- To characterise a diverse set of landraces for reproductive development under varied photoperiodic regimes
- To establish an efficient hybridization protocol for the genetic crossing of bambara groundnut
- To develop F_2 segregating mapping populations for photoperiod and other agronomic traits
- Detailed genetic analysis and identification of linked QTLs

Plant Materials



List of Landraces used, seed colours and centres of origin

S/N	Name	Seed Color	Origin/Remark
1	Tiga Necaru	Cream	Mali
2	Lun T	Cream	Sierra Leone
3	Ankpa 4	Brown	Nigeria
4	Getso	Cream	Nigeria
5	S19-3	Dark	Namibia
6	Dip C	Cream	Botswana
7	Uniswa Red	Reddish	Swaziland
8	IITA-686	Dark	Tanzania
9	Dodr	Red	Tanzania
10	Gresik	Dark	Indonesia

Source: Stadler (2010). Genetic groups compared with origin of accession

FutureCrop glasshouse suites for crop physiology

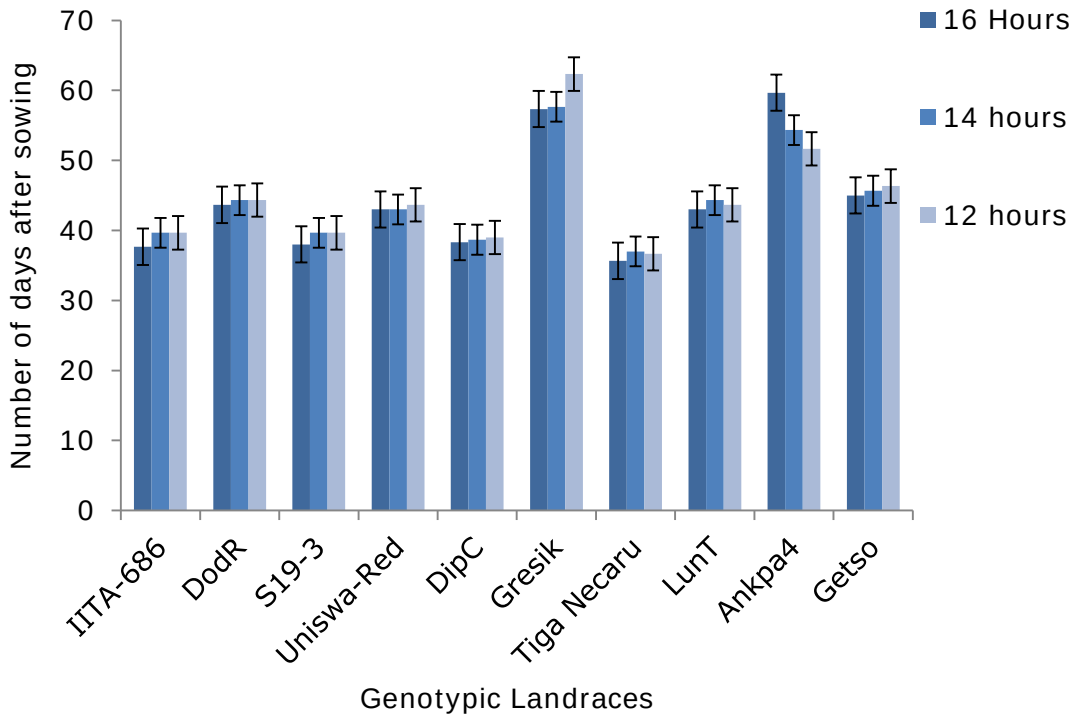
Environmental controls

- **Temperature**
- **Humidity**
- **CO2 Concentration**
- **Irrigation**
- **Ventilation rate**
- **Daylength**

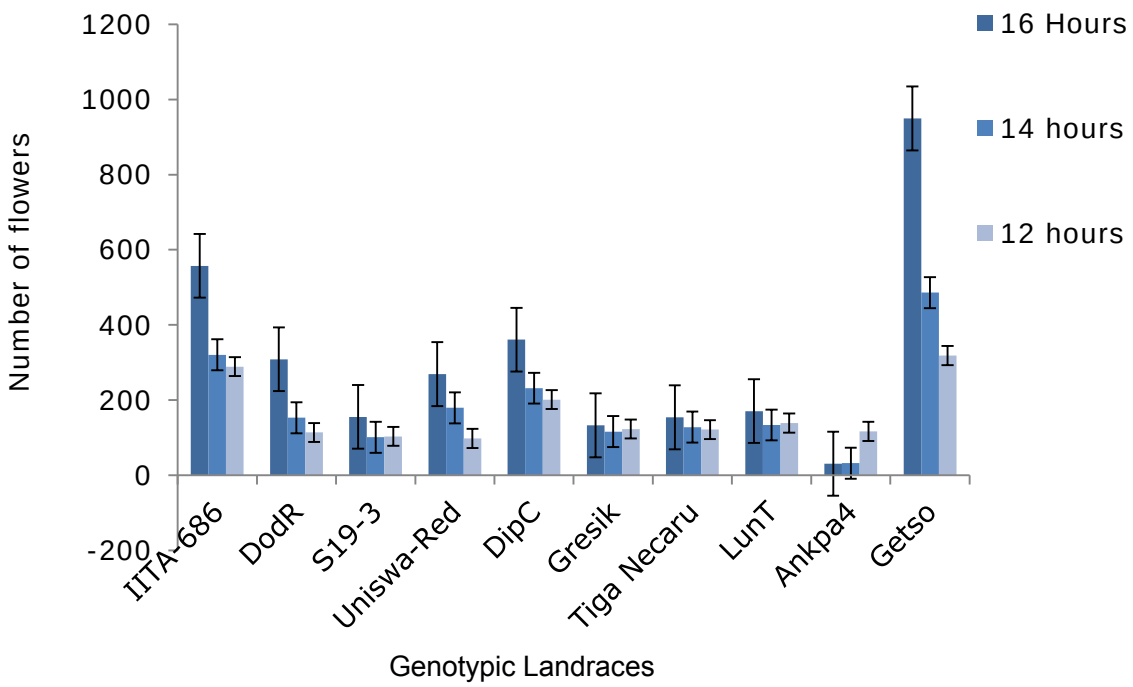
Plants grown on ground beds

Night

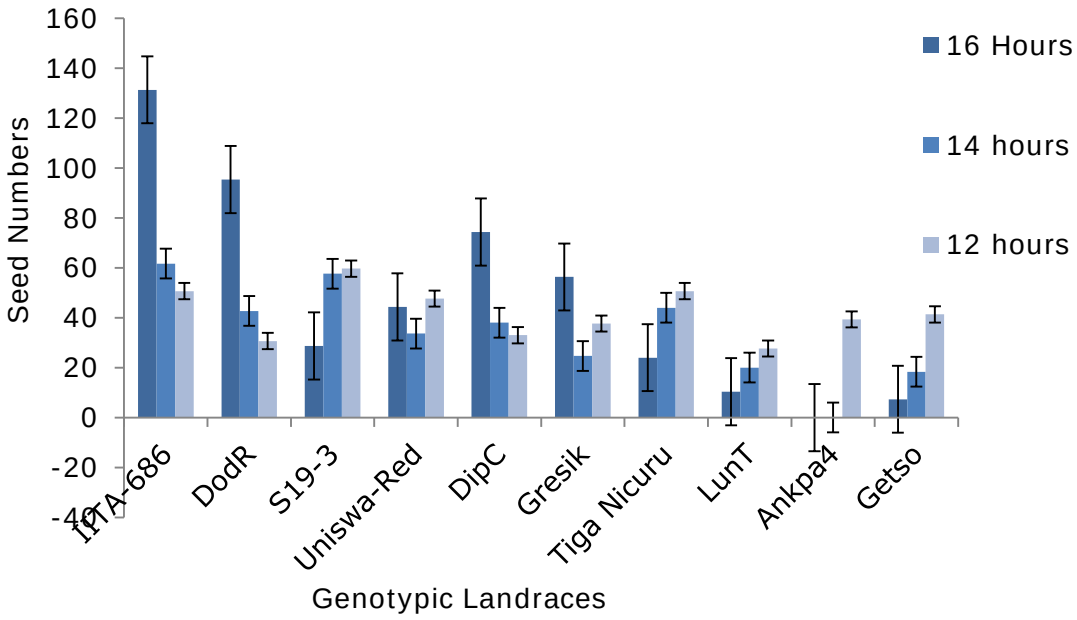
Flowering time



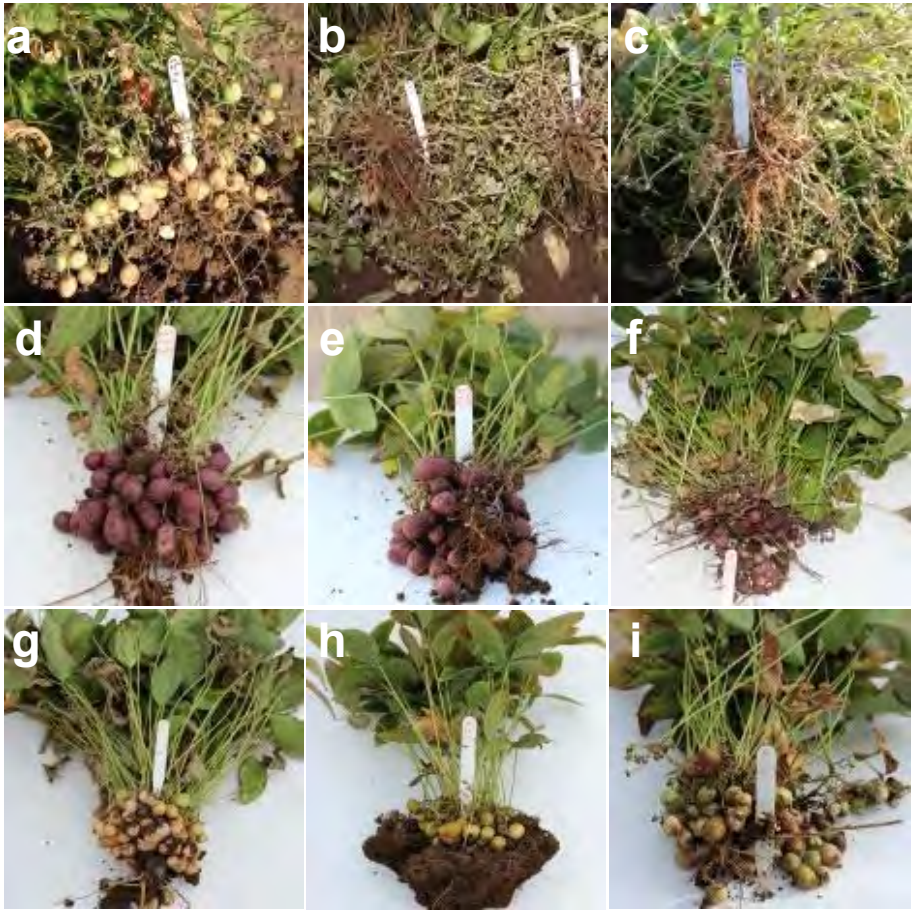
Total number of flowers



Photoperiod control of seed number



Reproductive success in bambara



Fruit set, fruit filling and maturity in bambara as a function of photoperiod: (A, B, & C) = Ankpa 4 in 12, 14 and 16 hours; (d, e, & f) = Uniswa Red in 12, 14 and 16 hours; (g, h, & i) = Dip C in 12, 14 and 16 hours

Four classes of genotypic landraces:

- Qualitative short day (e.g. Ankpa 4)
- Quantitative short day (e.g. TN, Lun T, Getso and Gresik)
- Quantitative long day (e.g IITA-686 and DodR)
- Photoperiod neutral (e.g. Dip C, Uniswa Red and S19-3)

IITA-686 under 16 Hours of Daylength

Genetic crossing of bambara in CE room

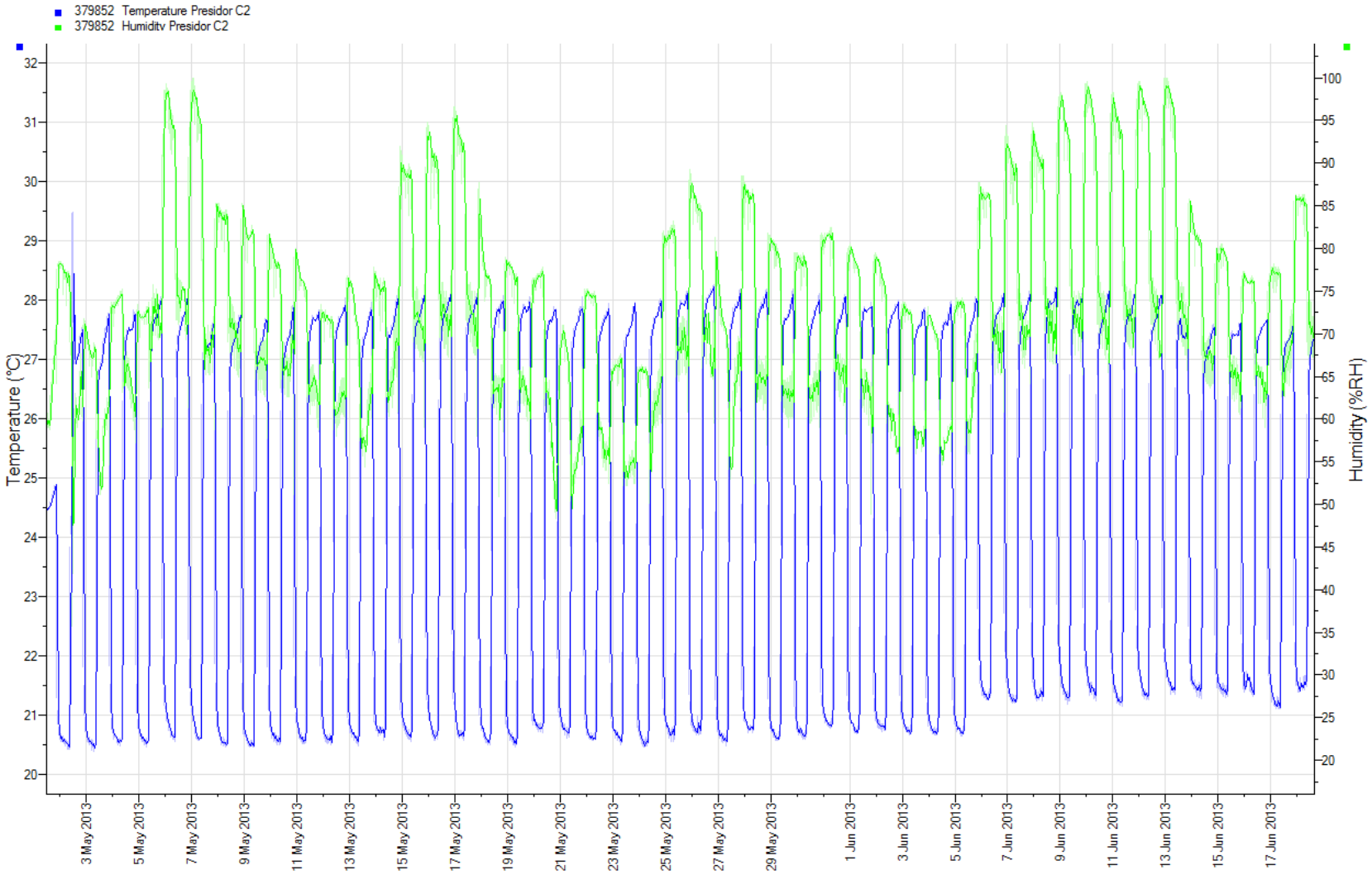
Plant materials and growth conditions:

- Ten genotypic landraces
- Soil mix: 1 Sand : 1 JI No.2 compost
- Temperatures @28°C (12 hours day) using artificial lights and 21°C night (12 hours)

Emasculation and pollination

Genetic crossing method: (a) matured flowers; (b) emasculation; © stigma of female parent; (d) adhesion of pollen on stigma.

CE room conditions



Daily room temperature and relative humidity in CE rooms 2013

Results of genetic crossing in bambara groundnut

day 1 of cross

3-5 days of cross

10 days after cross

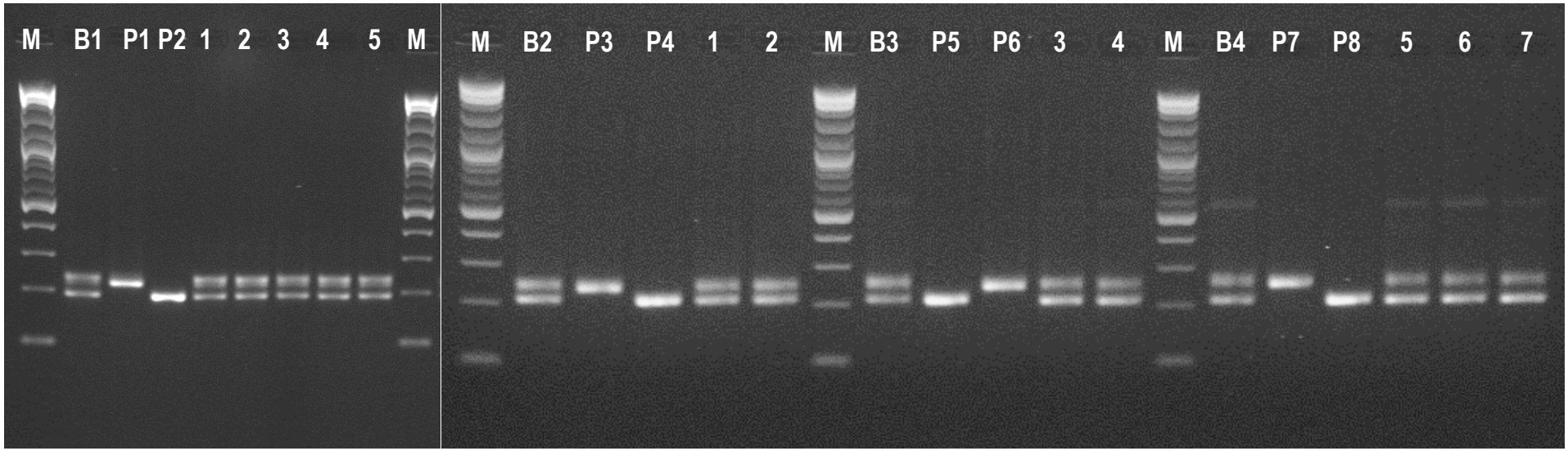
Table 2. Number of crosses crosses perfomed and number of pods set by hand-pollination in 2012

Crosses	Number of crosses performed	Mature pods set
Ankpa 4 X IITA-686	44	3
IITA-686 X Ankpa 4	35	4
Ankpa 4 X S19-3	34	2
S19-3 X Ankpa 4	38	3
Ankpa 4 X Dip C	10	1
Dip C X Ankpa 4	26	3
Lun T X IITA-686	15	0
IITA-686 X Lun T	47	10
Ankpa 4 X Uniswa Red	25	0
Uniswa Red X Ankpa 4	10	0
Ankpa 4 X DodR	25	2
DodR X Ankpa 4	31	0
Total	315	28 (8.9%)

Table 3. Number of crosses crosses perfomed and number of pods set by hand-pollination in 2013

Crosses	Number of crosses performed	Mature pods set
Uniswa X Gresik	12	0
Getso X Uniswa	13	0
Uniswa X Getso	10	1
S19-3 X Getso	25	3
S19-3 X Ankpa 4	20	2
Ankpa 4 X Dip C	11	1
Dip C X Ankpa 4	10	1
Uniswa Red X DodR	5	1
Total	106	9 (8.5%)

Microsatellite (Primer 15 & Primer 10) DNA profile of hybrids



Confirmation of hybrids: M=Markers; B1= DNA mix of IITA-686 & Ankpa 4; P1= IITA-686; P2 = Ankpa 4; (1-5) = hybrids of (P1) X (P2); B1= DNA mix of Dip C & Ankpa 4; P1= Dip C; P2 = Ankpa 4; (1 & 2) = hybrid of (P1) X (P2); B2= bulk DNA of IITA-686 & Lun T; P3= IITA-686; P4 = Lun T; (3 & 4) = hybrid of (P3) X (P4); B3= bulk DNA of S19-3 & Ankpa 4; P5= S19-3; P6 = Ankpa 4; (5, 6 & 7) = hybrid of (P5) X (P6)

Development of bambara groundnut hybrid

IITA-686 (♀)

X

Ankpa 4(♂)

F Hybrid

Dip C X Ankpa 4 Hybrids

Dip C (♀)

X

Ankpa 4(♂)

F1 Hybrid

Mapping resources

- IITA-686 (♀) X Ankpa 4 (♂)

F1 Hybrid Plant

Hybrid Vigor?

F2 pods: 537 + 23 = 560

- Dip C (♀) X Ankpa 4 (♂)

F1 Hybrid Plant

Hybrid Vigor?

F2 pods: 177 + 28 = 205

Conclusions (up to now...)

- Phenotypic characterization of ten bambara groundnut landraces in response to photoperiod has been completed
- Successful genetic crossing of bambara that yielded 37 F_1 hybrids from 8 cross combinations of highly divergent parents
- Development of 5 genetically segregating F_2 mapping populations, for important agronomic traits and photoperiod
- Phenotyping of F_2 mapping populations in progress
- Genotyping of mapping populations using SSRs and sequence-derived DArT markers
- Detailed genetic analysis, linkage mapping and Identification of linked QTLs

Policy Implications

- Establishment of bambara breeding programmes to breed for high yield and stability across different agroecological zones

- Bambara groundnut improvement could potentially make money or save money

- This will contribute directly to the economy of the poor resource base farmer in Africa

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