Overcoming the challenges of underutilised crop species: bambara groundnut (*Vigna subterranea* L.) as an example

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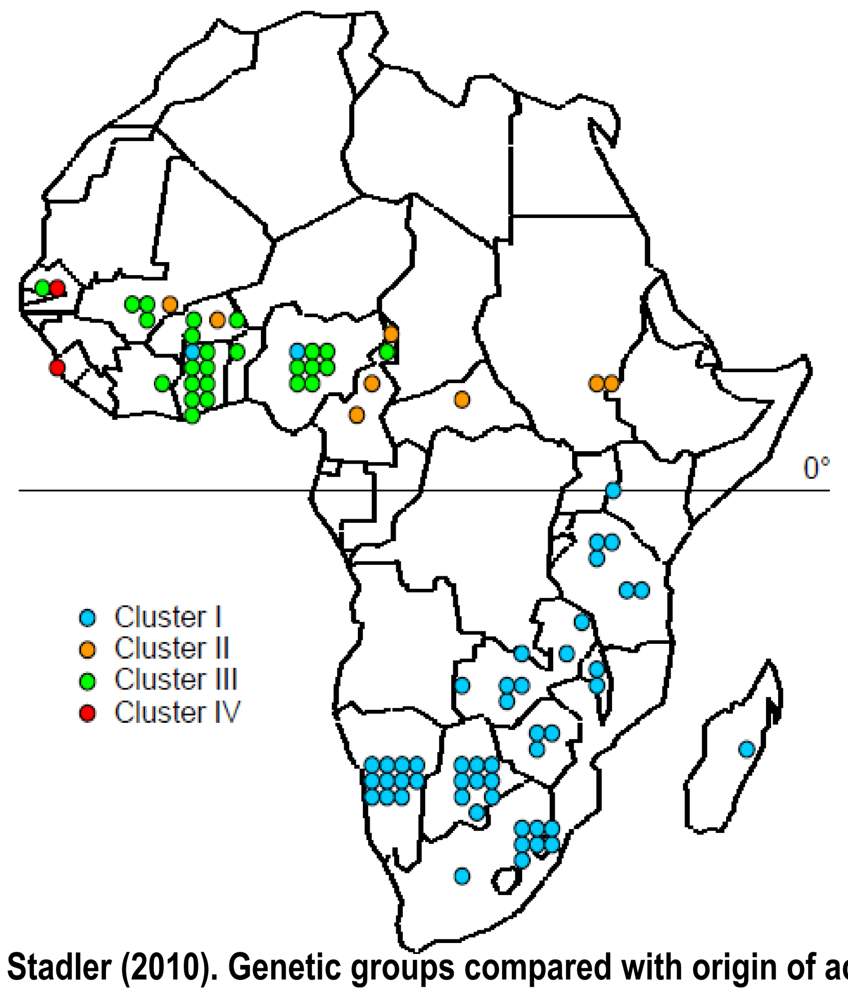
Introduction

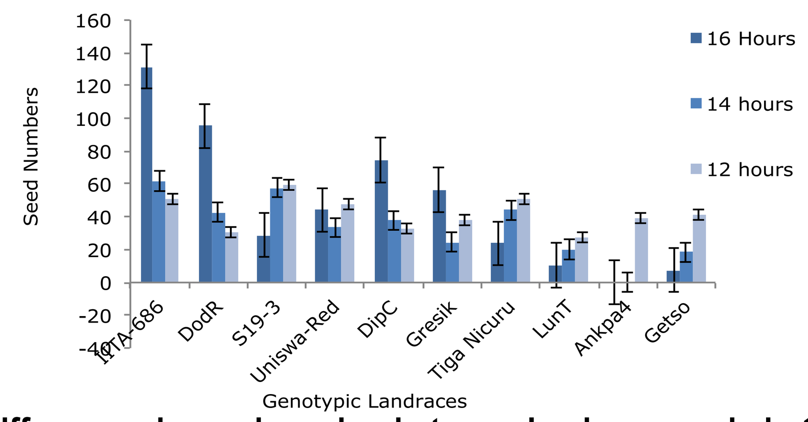
Yield trends of the four key global crops (rice, wheat, maize and soybean) are insufficient to double world food production and meet rising demand by 2050 (Ray *et al.*, 2013). One approach is to revisit minor crops that are an integral component of farming systems in the tropics, and bear a rich food, nutritional and cultural history for the poor resource base farmers in sub-Saharan Africa. A key component of plant adaptation is the way reproductive development is influenced by environmental factors. Photoperiod is one of the main factors influencing this development in bambara groundnut, an underutilised African legume rich in protein which grows on marginal soils. In this species, whilst incorrect daylength can delay flowering, it can completely prevent pod-filling. For small holder and subsistence farmers, where the sowing date of the crop is often determined by the timing of the rains, matching photoperiod requirement to daylength is important for reproductive success. Progress to alter photperiod requirement for pod filling to stabilize yields and improve uptake of this underutilised crop is presented.

Materials and Methods

Ten bambara groundnut landraces were used in this project. Photoperiod experiments were conducted on ground beds in three climate controlled glasshouses set at 12, 14, and 16 h of day length treatment. Each glasshouse was maintained at 50-70% relative humidity, 28ºC and 23ºC day and night temperatures, respectively. Plants were harvested at 150 days after sowing (DAS). Data were collected on days to emergence; days to first flower opening (anthesis); number of flowers at two day intervals; number of leaves at 20 day intervals, pod number, seed number, and above ground vegetative dry matter analysis. Artificial crossing was done on potted plants grown in CE rooms using parents that are highly divergent for photoperiod. Daylength and temperature conditions were the same as those found in 12 glasshouse.

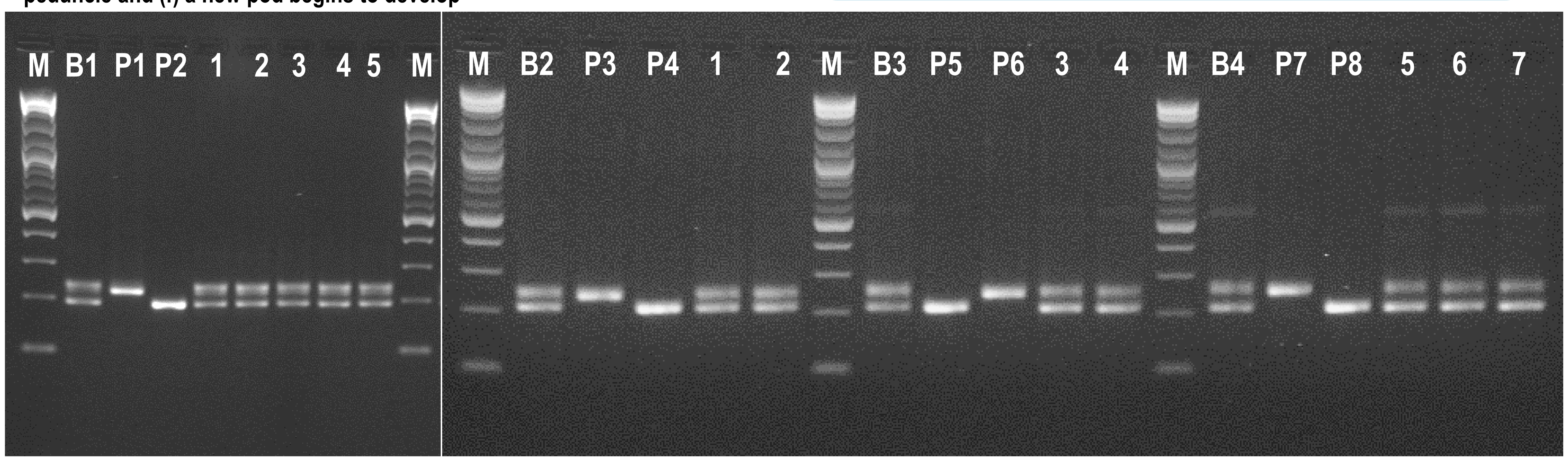


Source: Stadler (2010). Genetic groups compared with origin of accession

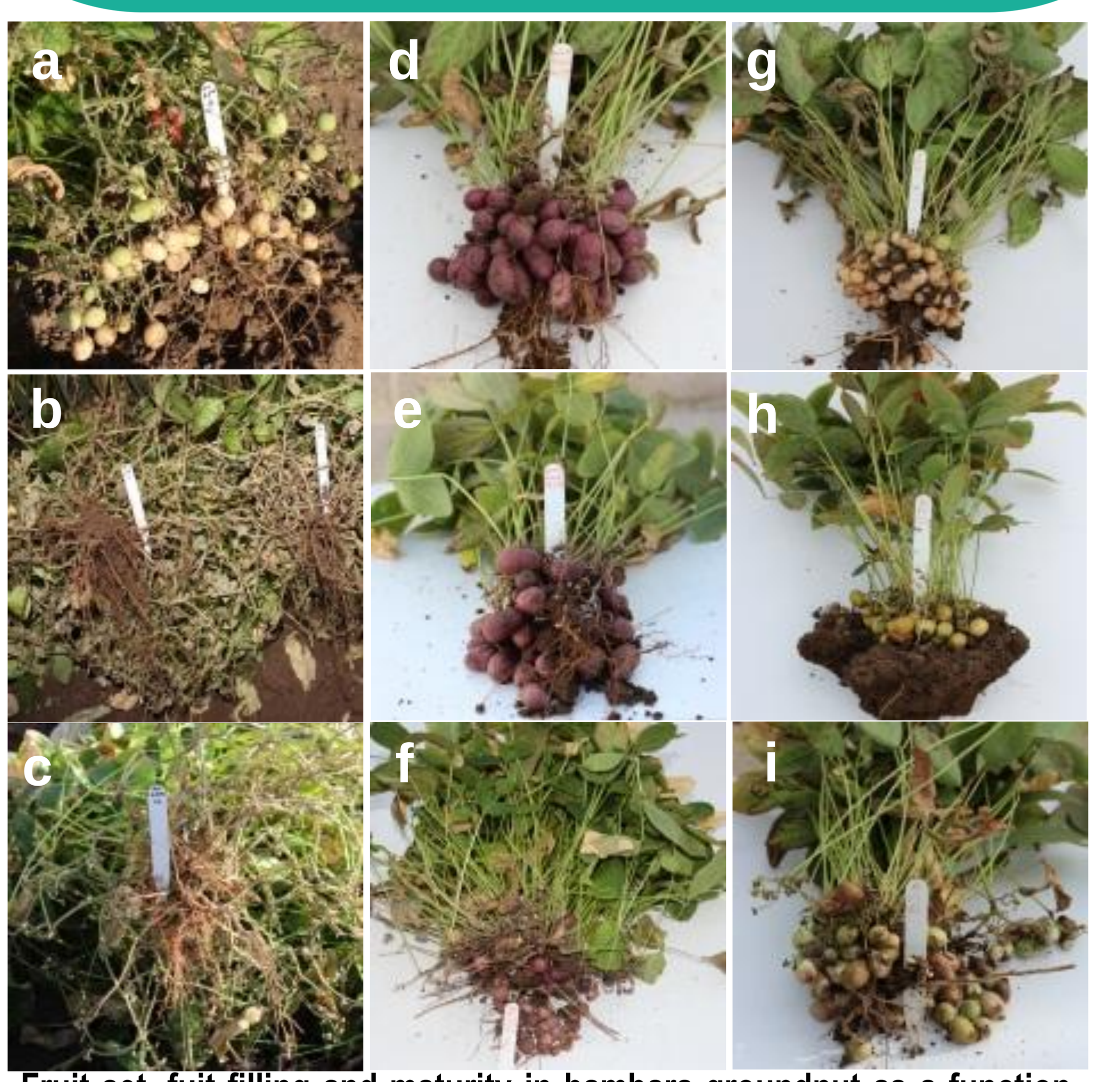


Differences in seed number between landraces and photoperiod treatment

Genetic crossing in bambara groundnut: (a) matured flower; (b) emasculation; © stigma of female parent; (d) adhesion of the pollen of male parent to the stigma of female parent; (e) pedicel bends towards the peduncle and (f) a new pod begins to develop



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) = hybrids of (P1) X (P2); B2= bulk DNA of IITA-686 & Lun T; P3= IITA-686; P4 = Lun T; (3 & 4) = hybrids of (P3) X (P4); B3= bulk DNA of S19-3 & Ankpa 4; P5= S19-3; P6 = Ankpa 4; (5, 6 & 7) = hybrids of (P5) X (P6)



Fruit set, fuit filling and maturity in bambara groundnut as a function of photoperiod: (a, b, & c) = Ankpa 4 in 12, 14, and 16 h; (d, e, & f) = Uniswa Red in 12, 14, and 16 h; (g, h, & i) = Dip C in 12, 14 and 16 h respectively

F1 Hybrid Plant: Dip C (♀) X Ankpa 4 (♂)

Hybrid Vigor?

F2 pods: 177 + 28 = 205

Table 1. Number of crosses performed and number of pod 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%)

Objectives

- To characterize a diverse set of landraces for reproductive development under varied photoperiodic regimes
- To select and utilize highly divergent parents in genetic crosses to develop a segregating F_2 population and;
- Develop tools for efficient molecular breeding and detailed genetic analysis.

Results

Four classes of genotypic landraces have been identified:

- Qualitative for short daylength (e.g. Ankpa 4)
- Quantitative for short daylength (e.g. TN, LunT Gresik and Getso)
- Quantitative for long daylength and a long reproductive period (e.g. IITA-686 and DodR)
- Photoperiod insensitive/day neutral, (e.g. S19-3, Uniswa-Red, and Dip C)

Novel F_1 hybrid materials have been generated through controlled crossing

Future Work

- Phenotyping of F2 segregating mapping populations in progress
- Genotyping of mapping populations using SSR markers and 64-bp sequence-derived DArT markers
- Detailed genetic analysis, linkage mapping and identification of linked QTLs using JoinMap and GENSTAT programs

Impact:

Knowledge of how photoperiod regulates the reproductive developmental processes of flowering, fruit-set, fruit-filling and maturity in bambara groundnut will impact on germplasm utilization for genetic improvement in relation to yield and adaptability to various latitudes.

References:

Stadler F. (2010). Analysis of differential gene expression under water-deficit stress and genetic diversity in bambara groundnut (*Vigna subterranea L*) using novel high-throughput technologies (Unpublished) Thesis, Technical University Munich.

Ray D.K., Mueller N.D., West P.C. and Foley J.A. (2013). Yield trends are insufficient to double global crop production by 2050. *Plosone* 8(6).