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Exploring phenotypic divergence in Bambara groundnut (*Vigna subterranea* [L.] Verdc.) for improved agronomic performance and cooking quality traits

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WATER RESEARCH COMMISSION

Introduction

The BGN is a drought tolerant legume with potential to produce higher grain yield under marginal conditions where most legumes would fail.

BGN is a ‘super food’ because it has all the essential nutrients in the right proportions.

BGN’s nutritional composition and ability to produce considerable yield under harsh environmental conditions, makes it a ‘crop of the future’.

Current Status of the BGN

Despite its potential contribution to food and nutrition security, the crop remains classified as orphaned crop species.

To date, there are no registered or improved BGN varieties.

Farmers still use landraces developed through mass selection over many generations.

An additional problem is that the BGN has the HTC phenomenon, which requires expensive and hard-to-obtain fuel to cook.

Way forward ?

Need to develop high yielding cultivars with improved cooking quality.

The development of new cultivars requires a clear understanding of the existing diversity to device an effective breeding strategy.

Several studies have existence of considerable divergence among BGN accessions.

However, very few studies have attempted to exploit this diversity in breeding.

The BamBREED Strategy

Main objective

- To identify BGN RILs with desirable agro-morphological and cooking quality traits to recommend for release as pure line cultivars.

Specific objectives

- To evaluate the genetic diversity among BGN recombinant inbred lines (RILs) using agronomic and morphological traits.
- To assess the cooking quality properties and nutritional composition of selected BGN RILs.

Materials and Methods

- **Planting material**

➢ 346 F5 RILs derived from four landraces from different locations in Africa and twenty-one check varieties, including the parents.

➢ The RILs were developed from crosses of four parents S19, ANKPA 4, IITA686, and Lun T and advanced using the single seed descent method to F5:6 generation.

- **Study site**

➢ The study was conducted at Ukulinga Research Farm in Pietermaritzburg, South Africa.

Materials and Methods cont..

- **Experimental design**

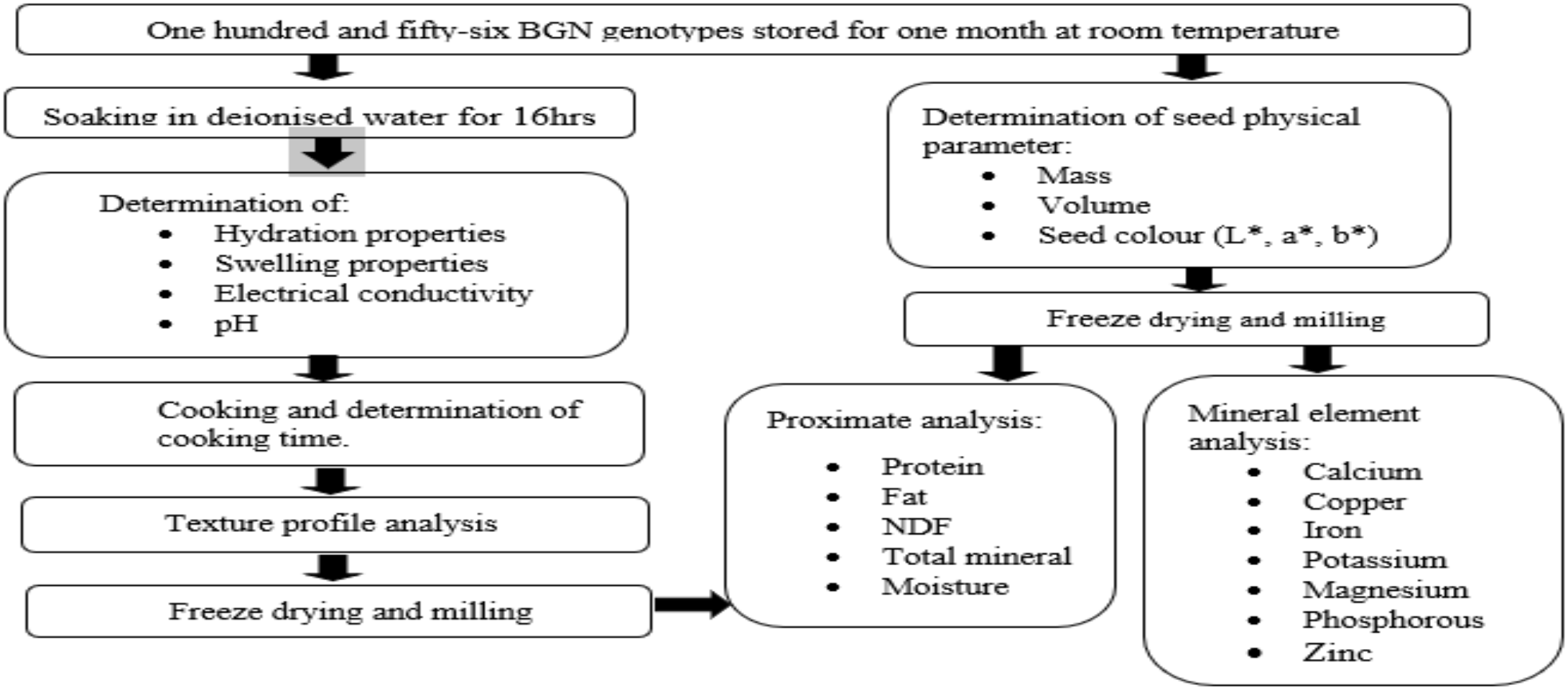
➢The experiment was laid out in a 73*5 augmented design.

- **Cooking time**

➢Cooking time was determined using the finger pressing method, and texture was measured using the texture analyser TA-TX2 (Stable Micro System, Surrey, England).

Quantitative trait	Code	Type of measurement	Notation	Procedure
Days to emergency	DE	Counting	Days	Number of days from planting to the first appearance of the first leaf on the soil Surface
Days to 50% flowering	DFF	Observation	Days	The number of days from emergency to when 50% of the plants have started flowering.
Internode length	IL	Tape measure	Cm	The average length of the 4th internode was randomly selected from the five longest stems at ten weeks.
Plant height	PH	Tape measure	Cm	The height of the main stalk from the surface to the tip of the main panicle.
Petiole length	PL	Tape measure	Cm	The average length of 3 leaves at the 4th node of the 5 healthy plants at 10 weeks.
Canopy width	CW	Tape measure	Cm	The average widest length between 2 opposite points of 5 plants at 10 weeks.

- Some of the Quantitative traits assessed



Cooking quality assay

Data analysis

All quantitative traits were subjected to ANOVA using the GLM procedure on R.

The frequency distribution and Shannon diversity index were calculated for qualitative traits .

Association among quantitative and qualitative traits were assessed using Pearson correlation coefficients.

Dimension reduction and cluster analysis was used to explore further the association in traits and RILs.

- Mean squares for eight quantitative traits of BGN RILs.

Source of variation	d.f	CW	DE	DF	IL	PH	PL	GY	GYP
Treatment	364	113.12$^{n.s}$	12.31**	116.15**	9.05**	11.92**	26.76**	831.77$^{n.s}$	59.4$^{n.s}$
Check	20	109.77$^{n.s}$	44.73**	382.95**	5.99**	37.19**	88.72**	2701.8**	179.19**
Test vs check	1	17.29$^{n.s}$	86.46**	780.68**	4.59**	48.11**	383.01**	9773.59**	691.61**
Test	343	113.6$^{n.s}$	10.2**	98.65**	9.24**	10.35**	22.1**	696.66**	50.5$^{n.s}$
Block	4	26.44$^{n.s}$	3.00**	19.57$^{n.s}$	0.74$^{n.s}$	5.99*	6.26$^{n.s}$	7814**	528.73**
Residual	82	105.25	2.69	18.3	0.46	2.2	5.52	806.75	51.76

n.s indicate non-significance p>0.05, ** indicate significance p<0.05. **d.f**: Degrees of freedom, **GCV**: Genotypic coefficient of variation, **PCV**: Phenotypic coefficient of variation, **CW**: Canopy width, **DE**: Days to emergence, **DF**: Days to 50% flowering, **IL**: Internode length, **PH**: Plant height, **PL**: Petiole length

Trait	Shannon-Weiner index (H’)
Growth habit	0.96
Terminal leaflet shape	1.19
Terminal leaflet colour	0.201
Average diversity index	0.78

- Shannon-Weiner diversity index

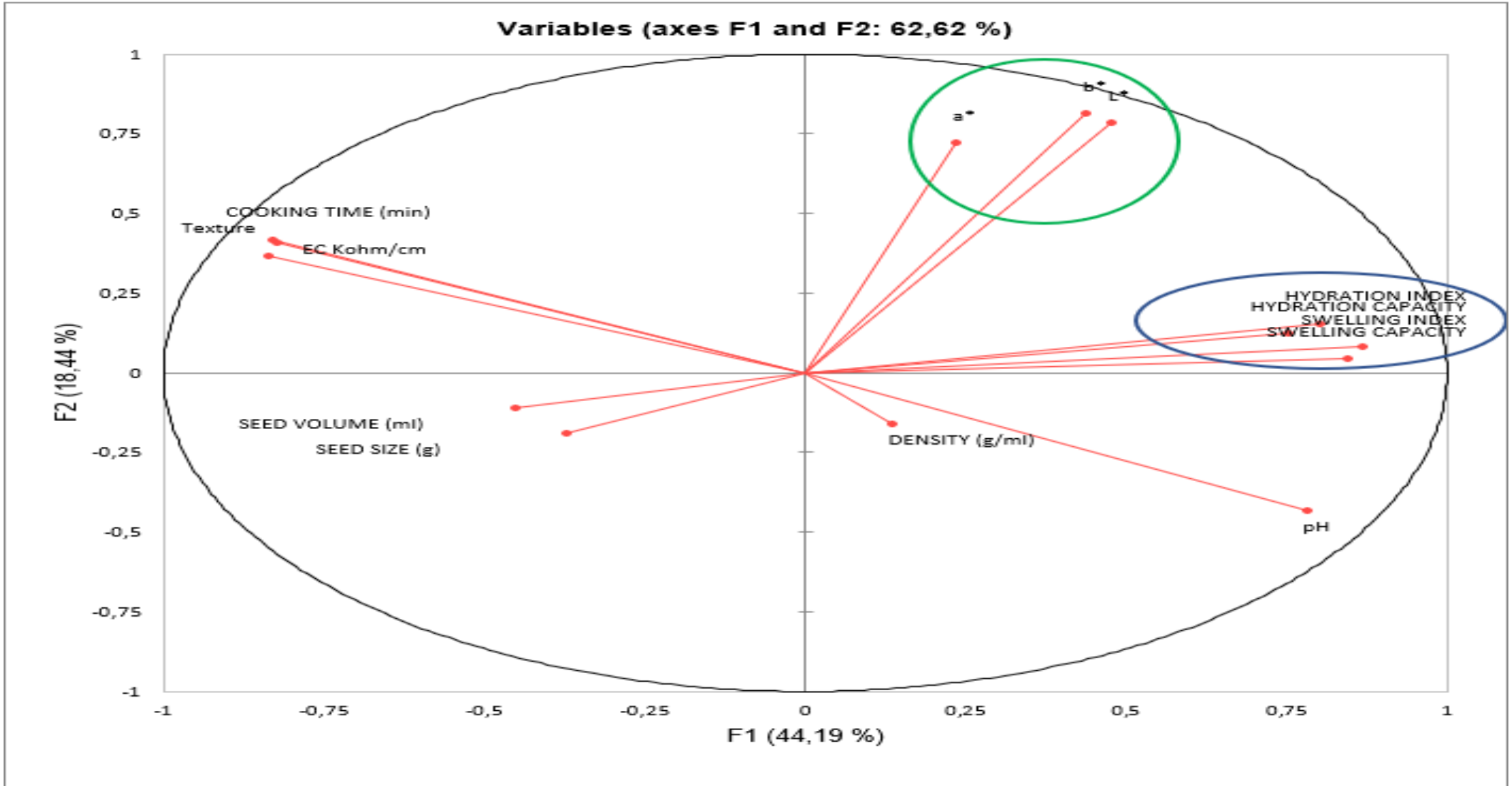
Traits	DE	DF	IL	PH	PL	CW	GY	GYP
DE								
DF	**0,867****							
IL	**-0,233****	**-0,246****						
PH	**0,749****	**0,862****	**-0,217****					
PL	**0,759****	**0,878****	**-0,214****	**0,854****				
CW	-0,007$^{n.s}$	-0,004$^{n.s}$	0,036$^{n.s}$	-0,040$^{n.s}$	-0,033$^{n.s}$			
GY	**0,216****	**0,259****	**-0,109****	**0,246****	**0,277****	0,003$^{n.s}$		
GYP	**0,210****	**0,254****	**-0,096****	**0,241****	**0,273****	-0,055$^{n.s}$	**0,870****	

- Pearson correlation coefficients (r) among eight quantitative traits.

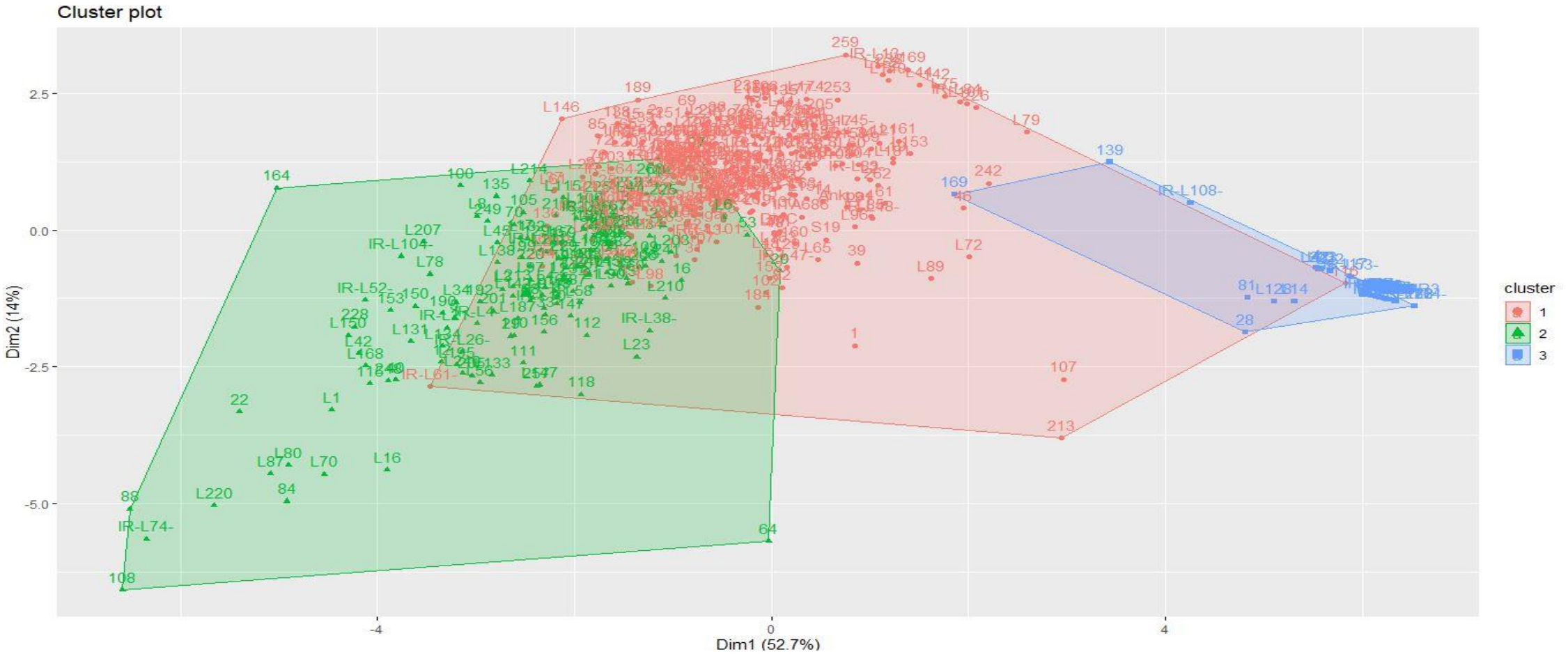
- Descriptive statistics for cooking quality traits

Parameters	Minimum	Maximum	Mean	Std. deviation
Seed size	0.250	0.830	0.511	0.102
Seed volume	0.230	0.670	0.407	0.084
Density	0.010	1.850	1.257	0.169
Hydration capacity	0.010	0.420	0.100	0.086
Hydration index	0.020	0.890	0.210	0.194
Swelling capacity	0.020	0.470	0.104	0.087
Swelling index	0.030	1.600	0.281	0.263
Cooking time (min)	40.000	147.000	88.410	18.581
EC	4.460	9.870	7.424	1.126
Ph	5.330	8.880	7.042	0.719
L*	13.920	58.450	29.534	13.244
a*	0.560	22.920	8.717	6.276
b*	-0.040	33.940	11.715	11.575
Texture	5.400	32.700	18.504	5.566

L: degree of lightness, **a**: degree of green-red, **b**: degree of blue-yellow



- Biplot for the first two principal components of the cooking quality parameters of Bambara groundnut genotypes



- Phenotypic clustering patterns among BGN RILs

Conclusions and recommendations

- The BGN RILS exhibit variation for agro-morphological and cooking traits, useful for identifying candidates for release.
- Association among traits will be important selection indices.
- There is need to introduce molecular markers for trait dissection and introgression.

Thank you!