Evaluating preharvest sprouting tolerance and thousand kernel weight in doubled haploid wheat populations

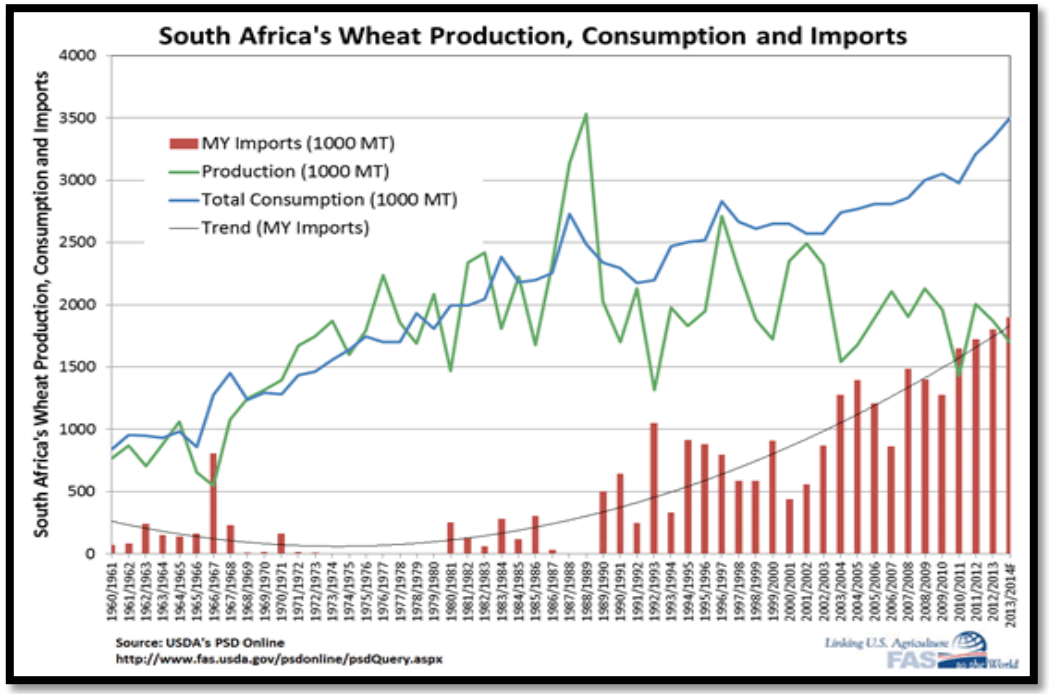
Thobeka P Khumalo[1,2], Annelie Barnard[1], Toi J Tsilo[1,2]

[1]ARC - Small Grain, Private Bag X29, Bethlehem, 9700, South Africa
[2]Department of Life and Consumer Sciences, University of South Africa, Pretoria, South Africa

13th International Gluten Workshop, 14 – 17 March 2018

Background

- Wheat is a staple food in South Africa and globally
- As a yield determinant, thousand kernel weight (TKW), can be used in estimating the amount of seeds required to plant m^{-2}
- Moreover, determining which cultivars yield more than others
- In South Africa, wheat area under dryland is about 80% (2 to 2,5 t/ha) and 20% under irrigation (5 t/ha) → annual wheat production of 1,3 to 3 million tonnes
- Over the past decade there was a decline in wheat production in South Africa – decrease in production area
- An increase in yield is necessary to meet the gradually and consistently increasing demand
  - (predicted food shortage by 2050 – Ray et al. 2013)



Background

- Preharvest sprouting (PHS) → germination of intact kernels on the plant ear upon humid and rainy conditions between maturity and harvest, greatly reduces grain quality and value

- The produced flour is unsuitable for baking purposes:
  - produces porous, runny and sticky dough, which results in products with a reduced volume and a dense interior

Effect of PHS on bread characteristics (front bread) *Image by Robbie Lindeque*

- Breeding for resistant cultivars is the sustainable solution
  - Mapping new sources of resistance (genes/QTLs) to PHS for the development of resistant wheat cultivars

Current South African situation of PHS

- PHS has been a serious production constraint especially in the summer rainfall regions where rain occurs frequently just prior to or during harvest time
- Significant progress has been made in managing PHS through breeding for tolerance or increased seed dormancy, especially under the current climatic conditions
- A wide range of genotypic variation in PHS has been achieved in South African cultivars
- Improvement from only 35% of cultivars showing tolerance in the early 1990's to over 84% of released winter wheat cultivars with high levels of PHS tolerance currently
- South African winter wheat cultivars can be categorised into three major groups: highly resistant, highly susceptible and moderate to PHS
  - The moderate group includes cultivars that are strongly influenced by the environment
- Remaining challenge is to release cultivars exhibiting both increased PHS tolerance as well as good yield characteristics, especially under the current changing climate

LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Study aim and objectives

Aim:

- The aim of this study was to examine the performance and select for DH lines with PHS tolerance and good yield characteristics for the ARC–Small Grain germplasm collection

Objectives:

- To plant the mapping populations in four sites representing different environments around the Free State Province for phenotypic evaluation of PHS and yield related traits
  - Arlington, Bethlehem, Clarens and Harrismith
- Phenotypic assessment of PHS and TKW
- Correlating the two traits

LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Material & Methods

- Trials were conducted in four sites in the Free State Province in June/July 2016
- Two doubled haploid (DH) mapping populations were used
  - Tugela-Dn/Elands (154 plants)
  - Elands/Flamink (65 plants)
- Experiment layout:
  - Single experiment per site
  - Arranged in a replicated control design (parents (checks) x 5 per population)
  - Each DH line and the parents sown in 1 m rows with an inter-row spacing of 0.45 m

LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

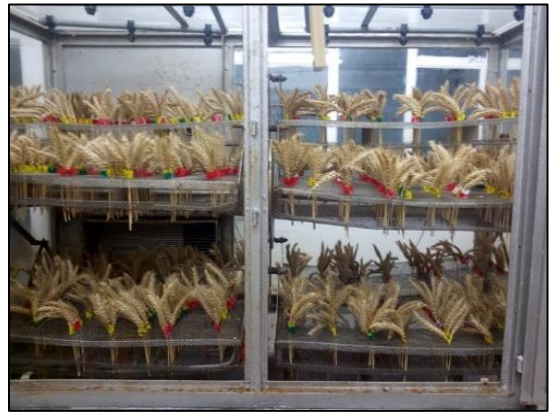
Material & Methods

Evaluating for PHS

Planting and monitoring field trials

Tagging in the field

Harvesting



Stacking in the rain simulator

At the end of exposure period, 72 hours

Out of the chamber, before scoring

Scoring 1 – 8 (Barnard et al., 1997)

Susceptible

Tolerant

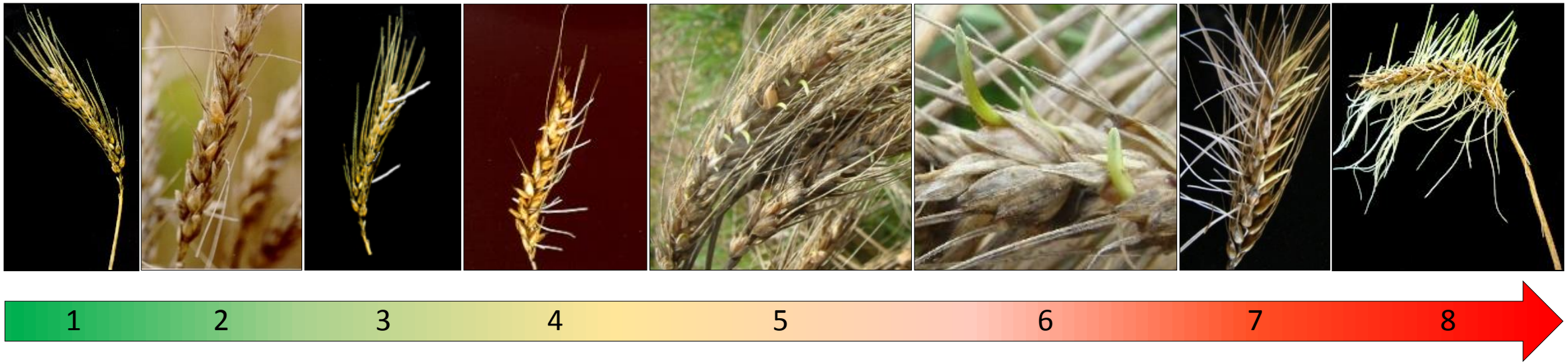
LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Material & Methods

Score used to rate for PHS tolerance/susceptibility

- Scores 1 – 3 = tolerant; 4, – 5 = moderate; 6 – 8 = susceptible



LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Material & Methods

Quantifying TKW

Planting and monitoring field trials

Tagging in the field

Harvesting

Threshing

Counting & weighing seeds

LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Results & Discussion

Statistical analysis of PHS

The GLM Procedure

Dependent Variable: PHS

R-Square	Coeff Var	Root MSE	PHS Mean
0.970579	25.49455	0.881617	3.458060

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	266.0537425	88.6845808	61.22	<.0001
Pop	1	32.9173153	32.9173153	22.72	<.0001
Site*Pop	2	7.0530156	3.5265078	2.43	0.0884
Pop(Site*Entry)	674	976.4162612	1.4486888		
Error	51	39.639667	0.777248		
Corrected Total	731	1347.322445			

Tukey Grouping	Mean	N	Study site
a	4.3970	203	Bethlehem
b	3.3320	150	Arlington
b	3.2709	196	Harrismith
c	2.7202	183	Clarens

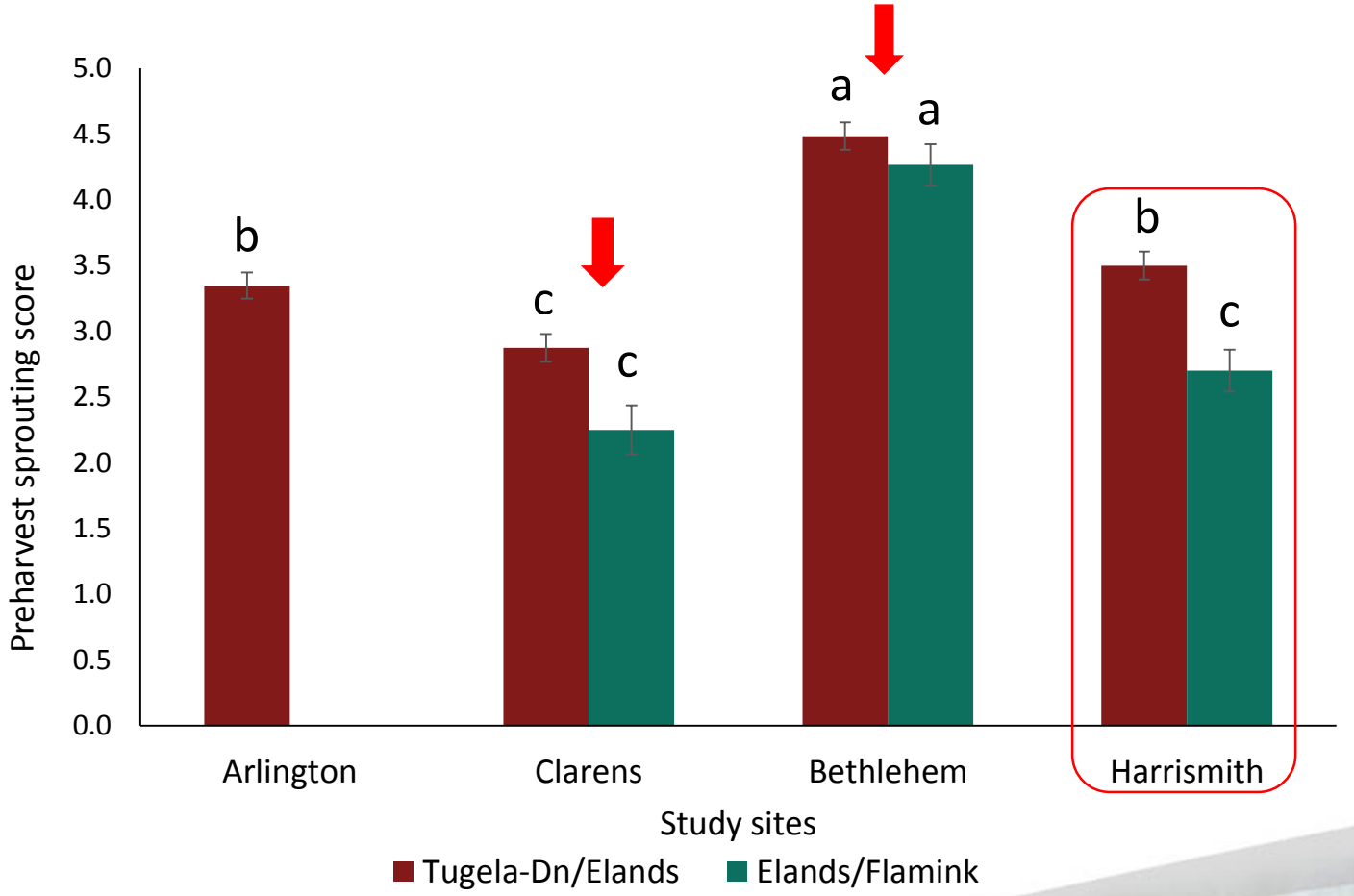
Tukey Grouping	Mean	N	Population
a	3.5489	560	Tugela-Dn/Elands
b	3.1622	172	Elands/Flamink

LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Results & Discussion

PHS tolerance of the two populations across the four study sites



LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Results & Discussion

Statistical analysis of TKW

The GLM Procedure

Dependent Variable: TKW

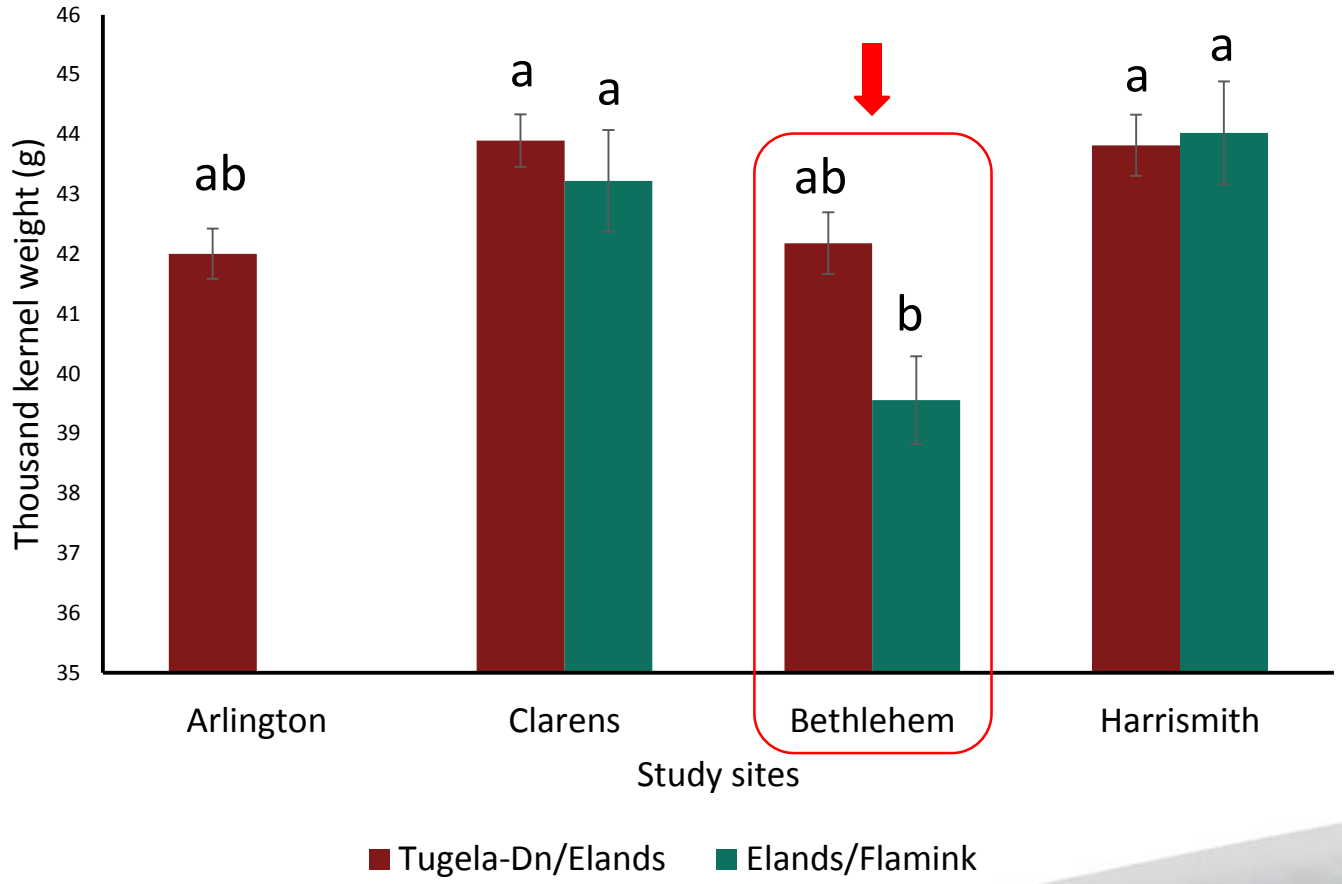
R-Square	Coeff Var	Root MSE	TKW Mean
0.840305	16.29143	6.984462	42.87200

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	3	795.2766150	265.0922050	10.98	<.0001
Pop	1	85.0167390	85.0167390	3.52	0.0611
Site*Pop	2	115.3430024	57.6715012	2.39	0.0928
Pop(Site*Entry)	539	13015.60022	24.14768		
Error	54	2634.26667	48.78272		
Corrected Total	599	16495.60960			

Tukey Grouping	Mean	N	Site
a	43.8176	170	Clarens
a	43.7986	138	Harrismith
b	42.2708	144	Arlington
b	41.5068	148	Bethlehem

Results & Discussion

TKW of the two populations across the four environments



LACC IGW

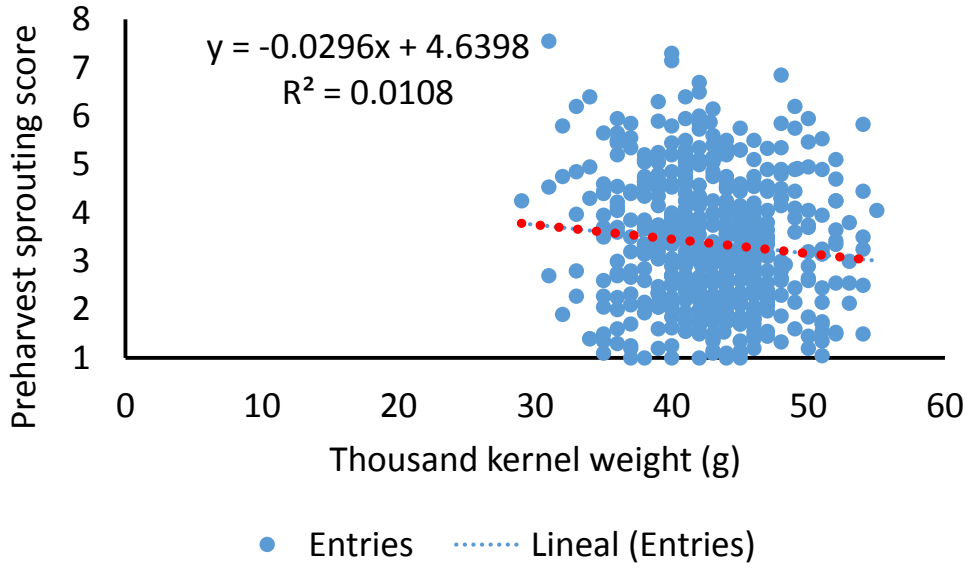
ARC • LNR
Excellence in Agricultural Research and Development

Results & Discussion

- A significant (p = 0.0029) correlation was observed
- The two traits displayed a negative correlation (-10,39%)

Study Site	PHS Mean	TKW Mean (g)
Clarens	2,7	43,8
Harrismith	3,3	43,8
Arlington	3,3	42,3
Bethlehem	4,4	41,5

Correlation between PHS and TKW in all entries used



- In overall, Clarens exhibited a desirable combination of good PHS tolerance (2.7) score and higher TKW (43.8g) in contrast to Bethlehem with poor PHS tolerance score (4.4) and a lower TKW (41.5g)
- Rating the performance of all entries in the studied sites: Clarens > Harrismith, Arlington > Bethlehem

Conclusions

- Perceived negative correlation (-10,39%) between the evaluated traits – PHS and TKW
- A potential combination of good PHS tolerance and high TKW yield was noted amongst some entries used – Clarens*
  - potential breeding material
- Study objectives successfully achieved

Way forward?

- 2nd year evaluations are underway…
- Evaluate more complimentary traits and test their correlation
  - efficient for selection purposes

LACC IGW

ARC • LNR
Excellence in Agricultural Research and Development

Acknowledgements

- Agricultural Reseach Council – Professional Development Program (ARC-PDP)

- National Research Foundation (NRF)

- Winter Cereal Trust (WCT)

- Dr Marde Booyse (Statistician)

- University of South Africa (UNISA)

- 13th International Gluten Workshop (IGW)

Thank You!

KhumaloT@arc.agric.za