

Matching Opposites

Defining the association between grain yield and protein content in South African wheat

Robbie Lindeque¹, Angeline van Biljon² and Maryke Labuschagne²

¹ ARC-Small Grain, Bethlehem, South Africa

² University of the Free State, Bloemfontein, South Africa



ARC-Small Grain, Bethlehem, South Africa

INTRODUCTION

Implications on commercial production and quality

Grain yield ranking compared with profit ranking of dryland wheat in the Free State (2014)

Early planting date (April) for the North-Western Free State				Late planting date (July) for the Eastern Free State			
Genotype	Yield ranking	ZAR ranking	ZAR ha ⁻¹	Genotype	Yield ranking	ZAR ranking	ZAR ha ⁻¹
SST 347	<u>5</u>	<u>1</u>	<u>9696.00</u>	SST 398	<u>3</u>	<u>1</u>	<u>13,024.00</u>
Matlabas*	6	2	8100.00	PAN 3368	5	2	12,704.00
SST 387	9	3	7031.50	SST 317	6	3	12,512.00
PAN 3161	2	4	6912.00	PAN 3111	<u>1</u>	<u>4</u>	<u>12,419.50</u>
PAN 3195	<u>1</u>	<u>5</u>	<u>6737.50</u>	Elands	8	5	12,064.00
PAN 3111	11	6	6394.50	SST 347	4	6	11,741.00
SST 398	18	7	6321.00	Senqu	11	7	11,616.00
PAN 3198	16	8	6183.00	PAN 3195	2	8	11,043.00
PAN 3120*	12	9	5940.00	SST 316	12	9	10,679.00
PAN 3368	19	10	5886.00	PAN 3379	12	10	10,620.00
SST 356	10	11	5373.00	Gariep	15	11	10,400.00
SST 316	15	12	5265.00	PAN 3161	7	12	10,206.00
PAN 3379	3	13	5049.00	Koonap	16	13	10,144.00
SST 317	7	14	4994.00	SST 356	9	14	10,098.00
Elands	17	15	4631.50	SST 387	14	15	9,504.00
Koonap	14	16	4401.00	PAN 3198	16	16	8,424.00
PAN 3118	3	18	4239.00				
Gariep	13	19	4131.00				

A difference of
ZAR 2958/ha =
USD 247/ha

A difference of
ZAR 604.50/ha =
USD 50.47/ha

Genotypes marked with an asterisk* are only adapted for early seeding dates

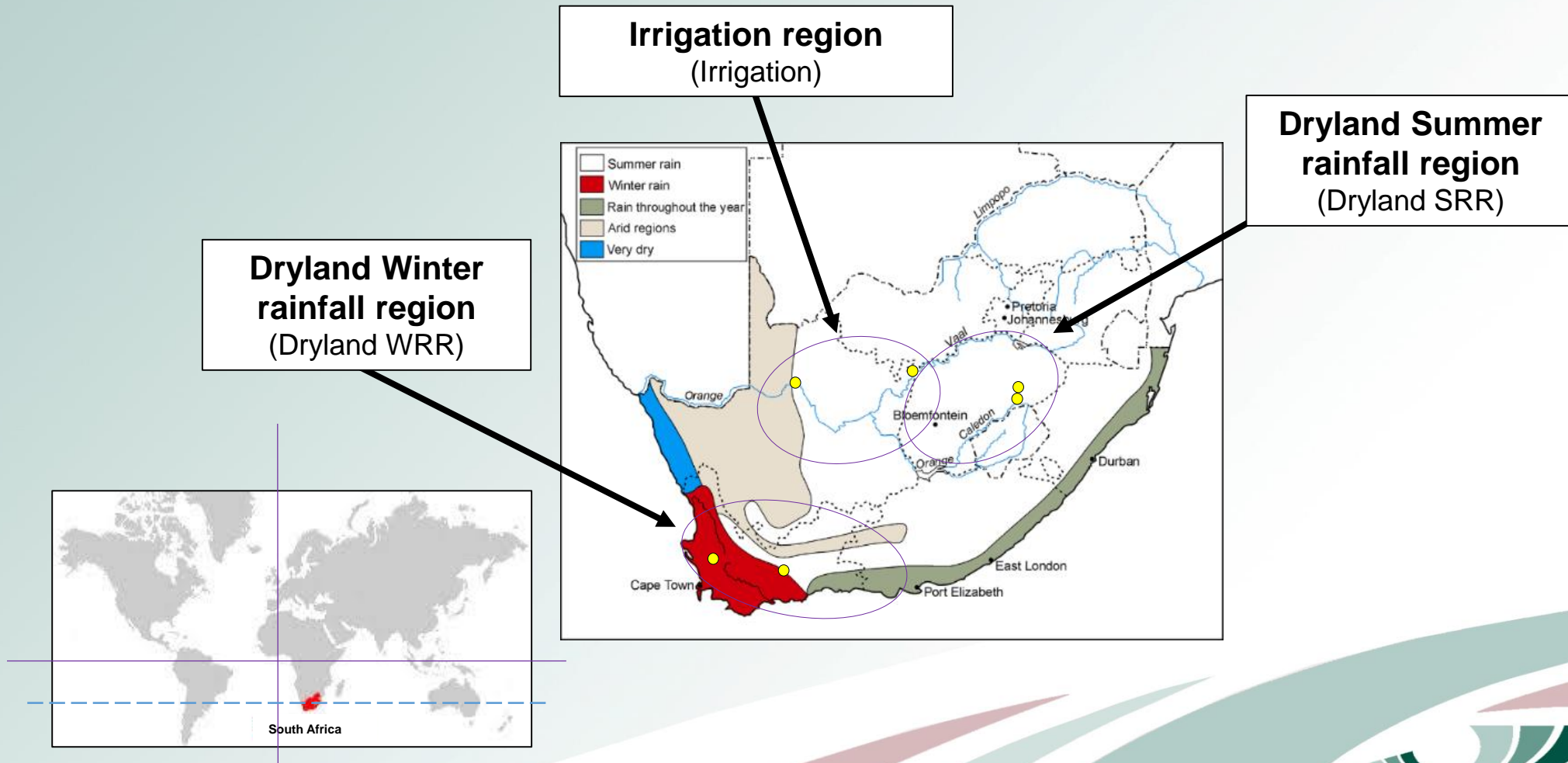
INTRODUCTION

Objectives of the study

1. Is the association between grain yield (GY) and grain protein content (GPC) evident in wheat from the three production regions in 2012 and 2013?
2. What are the general trends followed by the association between grain yield (GY) and grain protein content (GPC) for the three production regions?
3. Do protein concentrations of wheat with strong GY/GPC associations differ from wheat with weak GY/GPC associations?

MATERIAL AND METHODS

Where are we...?



MATERIAL AND METHODS

SDS-Soluble and Insoluble protein fractions

- SE HPLC on flour of all wheat samples

Statistical analysis

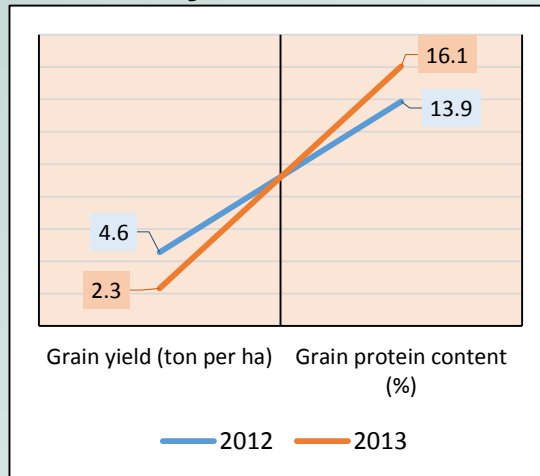
ANOVA and Correlations of protein fractions

- Genstats for Windows (18th version)
- Simple correlations

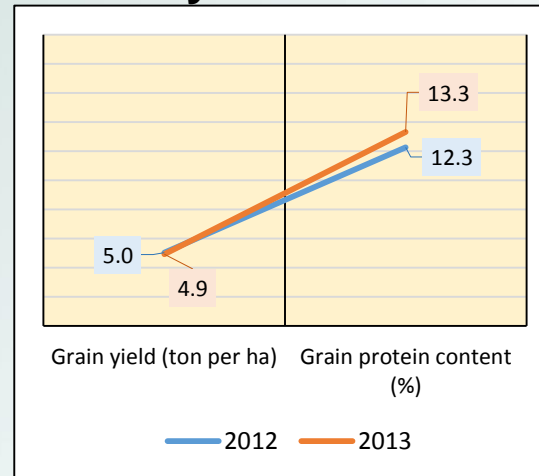
RESULTS

OBJECTIVE 1: Is the association between grain yield (GY) and grain protein content (GPC) evident in wheat from the three production regions in 2012 and 2013?

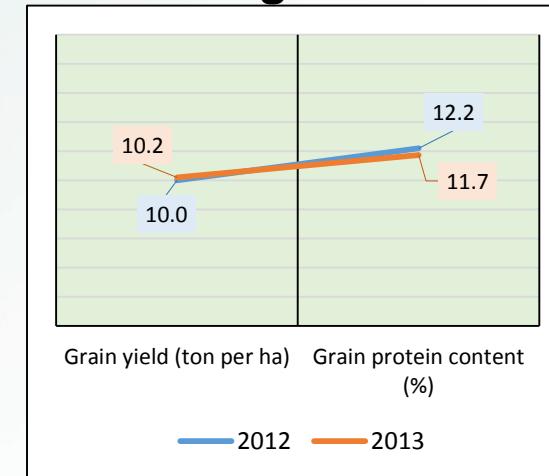
Dryland SRR



Dryland WRR



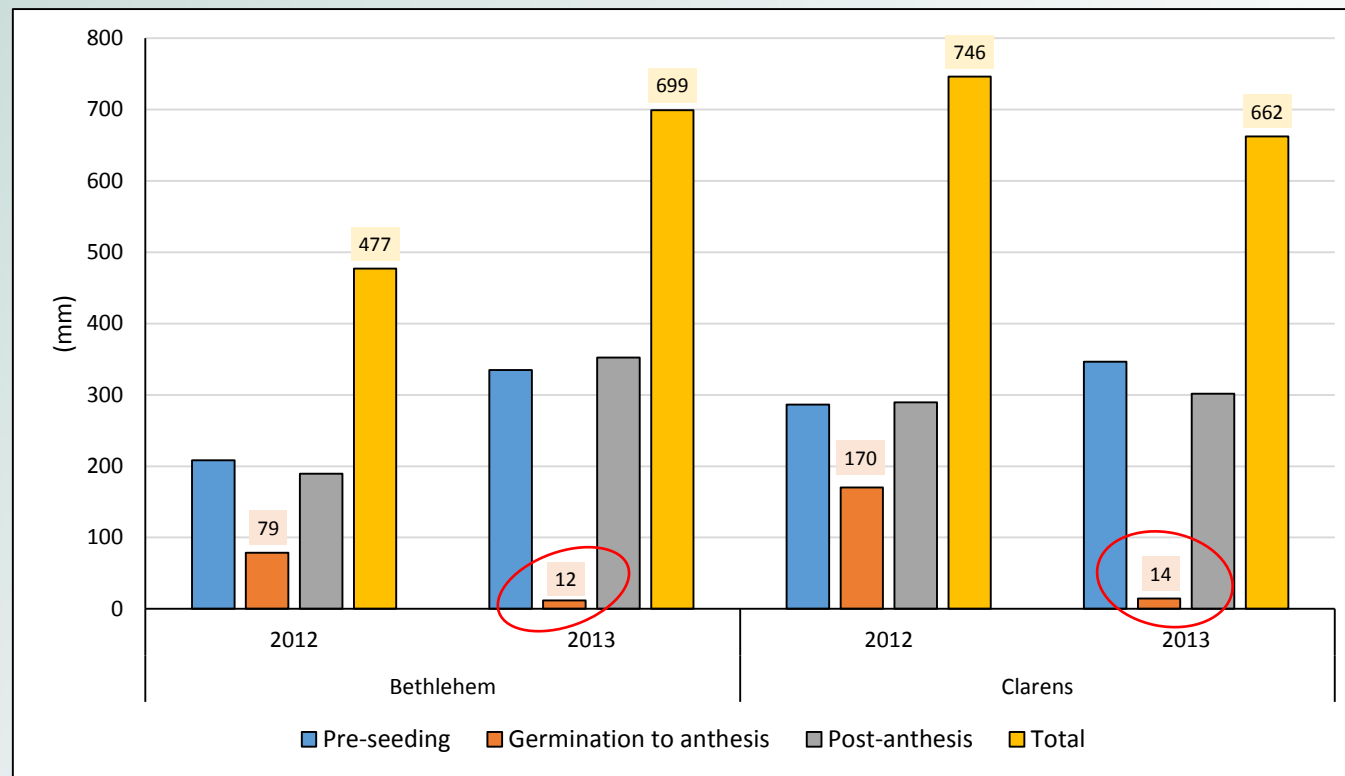
Irrigation



RESULTS

OBJECTIVE 1: Is the association between grain yield (GY) and grain protein content (GPC) evident in wheat from the three production regions in 2012 and 2013?

Rainfall distribution for Dryland SRR (2012 and 2013)



Pre-seeding: Jan to May, Germination to anthesis: Jun to Oct and Post-anthesis: Nov and Dec

RESULTS

OBJECTIVE 2: What are the general trends followed by the association between grain yield (GY) and grain protein content (GPC) for the three production regions?

Dryland SRR	2012				
	GY (t/ha)	-			
	GPC (%)	-0.63***	-		
	HLM (kg/hl)	0.27**	ns	-	
	FN (sec)	0.28**	-0.32**	ns	-
		GY (t/ha)	GPC (%)	HLM (kg/hl)	FN (sec)
Dryland WRR	2012				
	GY (t/ha)	-			
	GPC (%)	ns	-		
	HLM (kg/hl)	0.43***	0.29*	-	
	FN (sec)	ns	0.58***	0.33**	-
		GY (t/ha)	GPC (%)	HLM (kg/hl)	FN (sec)
Irrigation	2012				
	GY (t/ha)	-			
	GPC (%)	-0.61***	-		
	HLM (kg/hl)	ns	ns	-	
	FN (sec)	-0.46***	0.52***	ns	-
		GY (t/ha)	GPC (%)	HLM (kg/hl)	FN (sec)

	2013				
	GY (t/ha)	-			
	GPC (%)	-0.69***	-		
	HLM (kg/hl)	0.47***	-0.64***	-	
	FN (sec)	ns	-0.27*	ns	-
		GY (t/ha)	GPC (%)	HLM (kg/hl)	FN (sec)
	2013				
	GY (t/ha)	-			
	GPC (%)	0.41***	-		
	HLM (kg/hl)	0.41***	ns	-	
	FN (sec)	-0.72***	-0.47***	-0.39***	-
		GY (t/ha)	GPC (%)	HLM (kg/hl)	FN (sec)
	2013				
	GY (t/ha)	-			
	GPC (%)	-0.83***	-		
	HLM (kg/hl)	0.37***	-0.45***	-	
	FN (sec)	0.45***	-0.46***	ns	-
		GY (t/ha)	GPC (%)	HLM (kg/hl)	FN (sec)

GY: Grain yield, GPC: Grain protein content, HLM: Hectolitre mass, FN: Falling number, P-values: * - <0.05, ** - <0.01, *** - <0.001, ns – not significant

RESULTS

OBJECTIVE 3: Do protein concentrations of wheat with strong GY/GPC associations differ from wheat with weak GY/GPC associations?

	Strong Varietal Correlations (SVC)				Weak Varietal Correlations (WVC)			
	Variety	GY/ GPC correlation	GY (ranking)	GPC (ranking)	Variety	GY/ GPC correlation	GY (ranking)	GPC (ranking)
Dryland SRR	Elands	<u>-0.91***</u>	3.38 (9)	15.13 (5)	Senqu	<u>-0.76**</u>	3.63 (5)	15.39 (3)
	PAN 3161	<u>-0.91***</u>	3.66 (4)	14.87 (6)	SST 317	<u>-0.67*</u>	3.77 (2)	14.50 (10)
	PAN 3379	<u>-0.91***</u>	2.98 (12)	14.64 (9)	SST 356	<u>-0.67*</u>	3.45 (8)	13.95 (12)
	Average		3.34	14.88	Average		3.62	14.61
Dryland WRR	SST 015	<u>0.73**</u>	5.14 (5)	12.13 (9)	Kwartel	ns	4.27 (12)	13.24 (2)
	SST 047	<u>0.62*</u>	4.80 (10)	14.82 (1)	PAN 3471	ns	5.19 (1)	12.76 (8)
	Tankwa	<u>0.58*</u>	5.17 (3)	12.95 (4)	SST 096	ns	5.14 (6)	12.79 (6)
	Average		5.04	13.30	Average		4.87	12.93
Irrigation	Sabie	<u>-0.91***</u>	9.64 (17)	12.09 (5)	PAN 3471	ns	10.50 (5)	11.36 (16)
	SST 866	<u>-0.90***</u>	10.83 (2)	11.78 (11)	SST 806	ns	10.20 (10)	11.56 (15)
	SST 877	<u>-0.89***</u>	9.66 (15)	12.52 (3)	SST 876	ns	10.49 (6)	11.91 (9)
	Average		10.04	12.13	Average		10.38	11.61

GY: Grain yield (Ton per hectare), GPC: Grain protein content (%), P-values: * - <0.05, ** - <0.01, *** - <0.001, ns – not significant

RESULTS

OBJECTIVE 3: Do protein concentrations of wheat with strong GY/GPC associations differ from wheat with weak GY/GPC associations?

Solubility	Protein	Mean concentrations (%)								
		Dryland SRR			Dryland WRR			Irrigation		
		SVC	MVC	WVC	SVPC	SVNC	WVC	SVC	MVC	WVC
Insoluble fraction in total protein	LP - Glutenin	<u>5.47a</u> *	5.16ab	4.66b	ns			ns		
	SP - Glutenin	<u>17.21a</u> **	15.50b	16.21ab	ns			15.47b	<u>16.58a</u> *	15.84ab
	ω-Gliadin	<u>3.31a</u> *	3.09ab	2.99b	ns			3.15b	<u>3.40a</u> *	3.23ab
	α/β, γ - Gliadin	ns			ns			3.56ab	<u>3.68a</u> *	3.45b
	Albumin/globulin	<u>2.01a</u> *	1.72b	1.85ab	ns			ns		
	P value: * - <0.05, ** - <0.01, *** - <0.001, ns – not significant									

SVC group: Strong Varietal Correlation between grain yield and grain protein content

SVPC group: Strong Varietal Positive Correlation

SVNC group: Strong Varietal Negative Correlation

MVC group: Medium Varietal Correlation between grain yield and grain protein content

WVC group: Weak Varietal Correlation (medium to not significant) between grain yield and protein content

RESULTS

OBJECTIVE 3: Do protein concentrations of wheat with strong GY/GPC associations differ from wheat with weak GY/GPC associations?

Solubility	Protein	Mean concentrations (%)								
		Dryland SRR			Dryland WRR			Irrigation		
		SVC	MVC	WVC	SVPC	SVNC	WVC	SVC	MVC	WVC
Soluble fraction in total protein	LP - Glutenin	ns			ns			6.80ab	6.43b	<u>7.03a</u> **
	SP - Glutenin	15.41b	14.82b	<u>16.61a</u> **	15.31b	15.79ab	<u>16.19a</u> **	16.71ab	16.12b	<u>17.27a</u> **
	ω-Gliadin	ns			ns			Ns		
	α/β, γ - Gliadin	27.40b	<u>30.01a</u> ***	28.39ab	28.34ab	<u>28.56a</u> *	27.04b	<u>26.52a</u> **	26.40a	25.25b
	Albumin/globulin	ns			ns			13.15ab	12.38b	<u>13.46a</u> *
	P value: * - <0.05, ** - <0.01, *** - <0.001, ns – not significant									

SVC group: Strong Varietal Correlation between grain yield and grain protein content

SVPC group: Strong Varietal Positive Correlation

SVNC group: Strong Varietal Negative Correlation

MVC group: Medium Varietal Correlation between grain yield and grain protein content

WVC group: Weak Varietal Correlation (medium to not significant) between grain yield and protein content

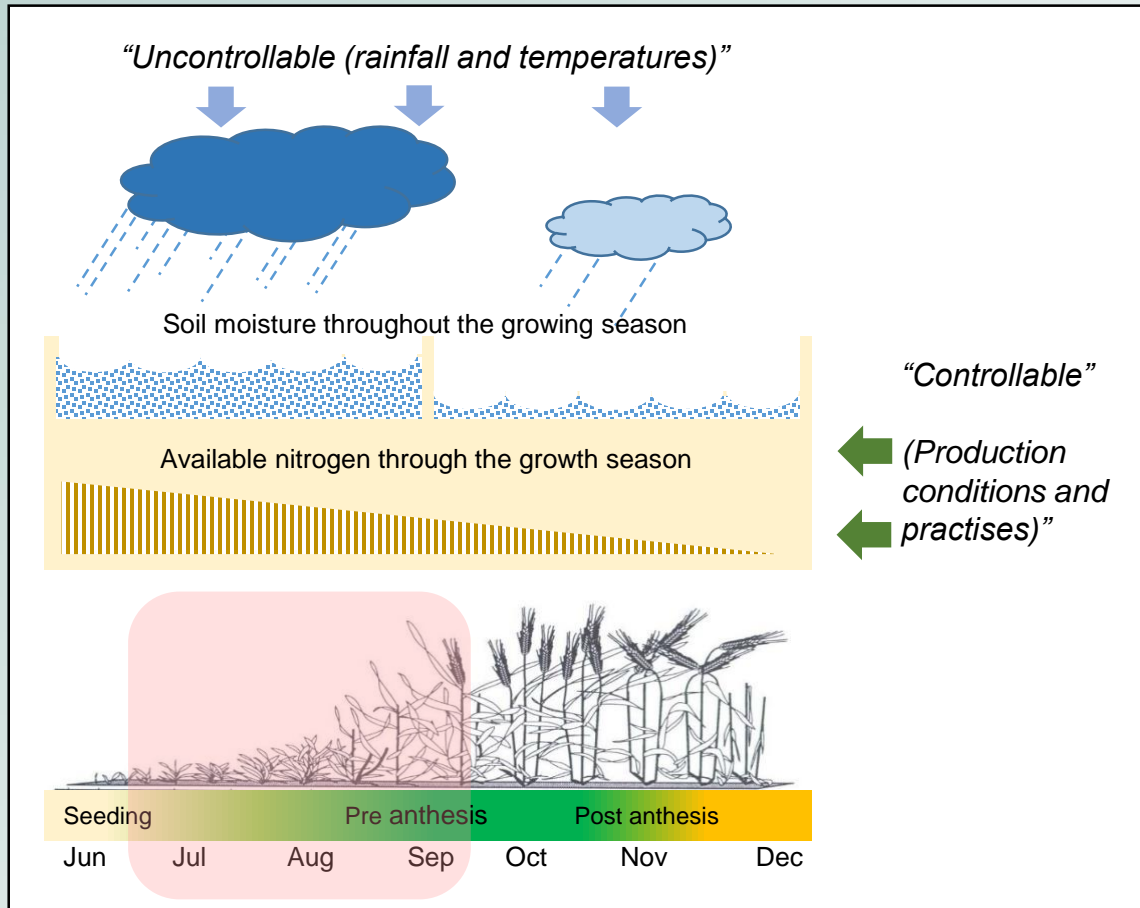
CONCLUSIONS

Meeting the objectives of the study

1. Is the association between grain yield (GY) and grain protein content (GPC) evident in wheat from the three production regions in 2012 and 2013?
- *Yes, although much less in dryland wheat from the WRR*
2. What are the general trends followed by the association between grain yield (GY) and grain protein content (GPC) for the three production regions?
- *Negative correlations for Dryland SRR and Irrigation regions but weak and positive for the Dryland WRR region*
3. Do protein concentrations of wheat with strong GY/GPC associations differ from wheat with weak GY/GPC associations?
- *Yes*

CONCLUSIONS

Do protein concentrations of wheat with strong GY/GPC associations differ from wheat with weak associations?



"Deviation from the grain protein concentration–grain yield negative relationship is highly correlated to post-anthesis N uptake in winter wheat"

"Breeding for higher post-anthesis N uptake without reducing total N at anthesis. The physiological mechanisms related to post-anthesis N uptake seem to be independent from anthesis date and total N at anthesis"

(Bogard et al, 2010. J Exp Bot, 61:15, pp. 4303–4312)

FUTURE RESEARCH INTERESTS

Grain yield vs grain protein content

Is “more” better?

12% protein is the limit for the B1 grade or can there be a premium for protein above 12% ?

What are the primary genetic backgrounds contributing to GPC in SA wheat varieties?

Unravel the associations between soil moisture, fertiliser rates and application timing and GPC

Identify genotypes with weak correlations between GY and GPC (adapted vs introduced)

Use these genotypes in a dedicated crossing programme

Identify the nutritional status of wheat from the three production regions in SA

Currently a MSc thesis is conducted on the topic by Mr Timmy Baloyi

ACKNOWLEDGEMENTS

Funding for IGW, Mexico City 2018

- Winter Cereal Trust
- National Research Foundation



Contributions by colleagues



Dr Barend Wentzel (SE-HPLC) and
Mrs Chrissie Miles (Quality analyses)



Mr Timmy Baloyi (Nutritional information and
assistance with funding)

Prof Maryke Labuschagne and Dr Angie van Biljon (Rendition of data and results)

Approval and support to attend IGW

- ARC-Small Grain management