RELATIONSHIP BETWEEN GRAIN YIELD AND PROTEIN QUANTITY AND QUALITY IN COMMERCIAL WHEAT

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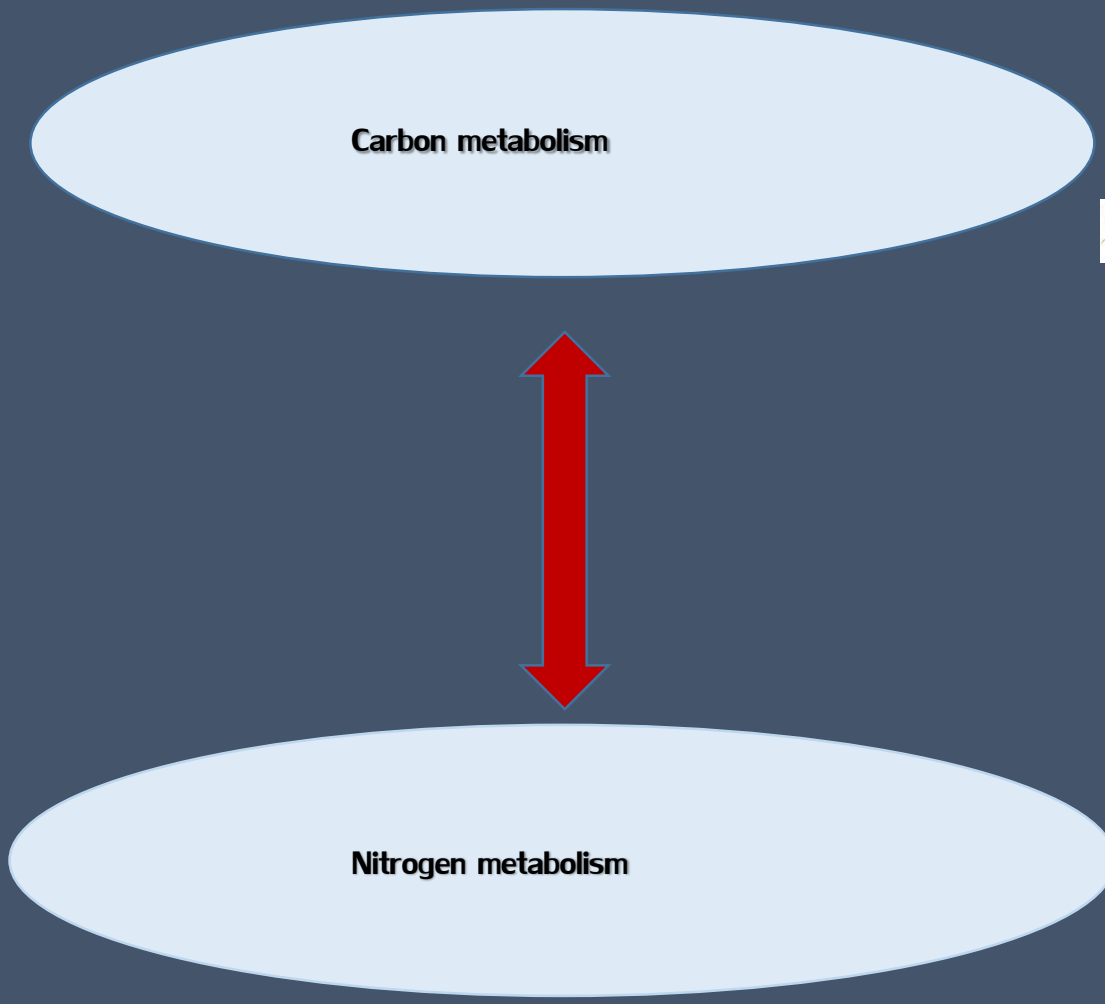


- Competition between carbon and nitrogen for energy
- Dilution effect of nitrogen by carbon based compounds
- Leads to negative correlation between yield and protein content

AIMS OF THE STUDY

- To establish, in South African commercial bread wheat cultivars, the association of grain yield with grain protein

- In the same material to establish the relationship between grain yield and SDS insoluble and soluble polymeric and monomeric proteins

MATERIALS AND METHODS

UFS UV


SOUTH AFRICA
BOTSWANA
MOZAMBIQUE
NAMIBIA
SWAZILAND
LESOTHO
Kruger National Park
Gaborone
Kgalagadi Transfrontier Park
Pretoria
Johannesburg
Soweto
Nelspruit
Mbabane
Maputo
Greater St Lucia Wetland Park
Ladysmith
Bergville
Drakensberg
Upington
Springbok
Bloemfontein
Orange River
Durban
Umtata
Lusikisiki
Port St Johns
INDIAN OCEAN
The Shipwreck Coast
Grahamstown
East London
Garden Route
Cape Town
Mossel Bay
George
Port Elizabeth
Jeffrey's Bay
Cape of Good Hope
Cape Agulhas
0 250 km
0 150 miles

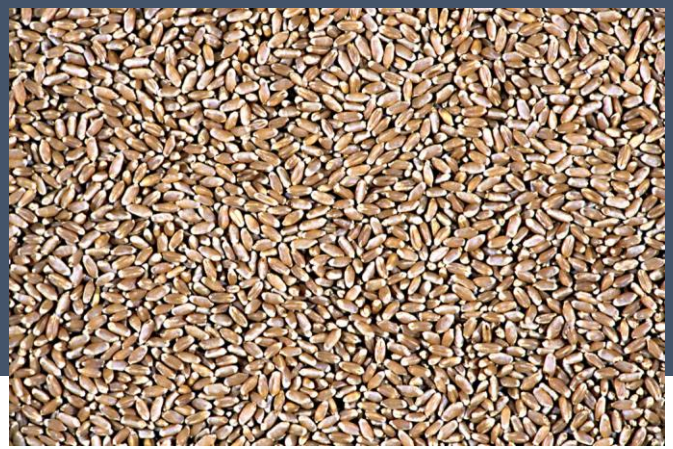
Trial	Test site	GPS coordinates	Elevation (masl)	Planting	Harvesting	Cultivars
Dryland summer rainfall	Bethlehem	28˚09'18.67"S 28˚17'59.99"E	1641	Early July 2012 2013	Early January 2013 2014	12
	Clarens	28˚31'0" S 28˚25'0" E	1812	Early July 2012 2013	Early January 2013 2014	
Dryland winter rainfall	Riversdale	34˚6'37.31" S 21˚15'16.89' E	209	End May 2012 2013	Mid November 2012 2013	12
	Moorreesburg	33˚8'60" S 18˚40'0" E	151	Mid May 2012 2013	End November 2012 2013	
Irrigation	Upington	28˚27'0" S 21˚15'0" E	801	Early May 2012 2013	End November 2012 2013	18
	Vaalharts	27˚56'47.96" S 24˚48'12.001" E	1141	Early May 2012 2013	Mid November 2012 2013	

- Wheat in irrigation and winter rainfall areas planted at 100-120 kg/ha

- Wheat in summer rainfall area planted at 20-30 kg/ha N

- Total N provided per season through fertilization:

  - Irrigation region 280 kg N/ha
  - Winter rainfall area 130 kg N/ha
  - Summer rainfall region 60 kg N/ha



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- Protein content calculated from total N using a macro Kjeldahl procedure (AACCI Method 46-10)
- Nitrogen per grain calculated from total yield, total N and 1000 kernel mass for all cultivars
- Yield calculated as ton/ha
- All trials done for 2 locations per region for 2 seasons

Protein fraction	% Protein ratio	Calculations
A: Larger polymeric proteins (LPP), i.e HMW glutenin subunits	% soluble fraction in total soluble protein	<u>In soluble or insoluble protein:</u> Soluble or Insoluble fraction/(LPP + SPP + ω gliadin + α/β, γ gliadin + albumin and globulin)*100
B: Smaller polymeric proteins (SPP), i.e LMW glutenin subunits	% insoluble fraction in total insoluble protein	
C: ω Gliadin (larger monomeric proteins)	% soluble fraction in total protein	<u>In total protein:</u> Soluble or insoluble fraction/[(soluble: LPP + SPP + ω gliadin + α/β, γ gliadin + albumin and globulin)+(insoluble: lpp + spp + ω gliadin + α/β, γ gliadin + albumin/globulin)]*100
D: α/β, γ Gliadin (I arger monomeric proteins)	% insoluble fraction in total protein	
E: Albumin and globulin (Smaller monomeric proteins)	% insoluble fraction in total same fraction	<u>In total same fraction:</u> Insoluble fraction/(corresponding soluble fraction + corresponding insoluble fraction)*100
Total	% insoluble A and B in total glutenin	<u>In total glutenin (LPP + SPP):</u> Insoluble A + insoluble B/(Insoluble A + insoluble B + soluble A + soluble B)*100

RESULTS

Environment contributed most to variation in grain yield and protein content in all regions

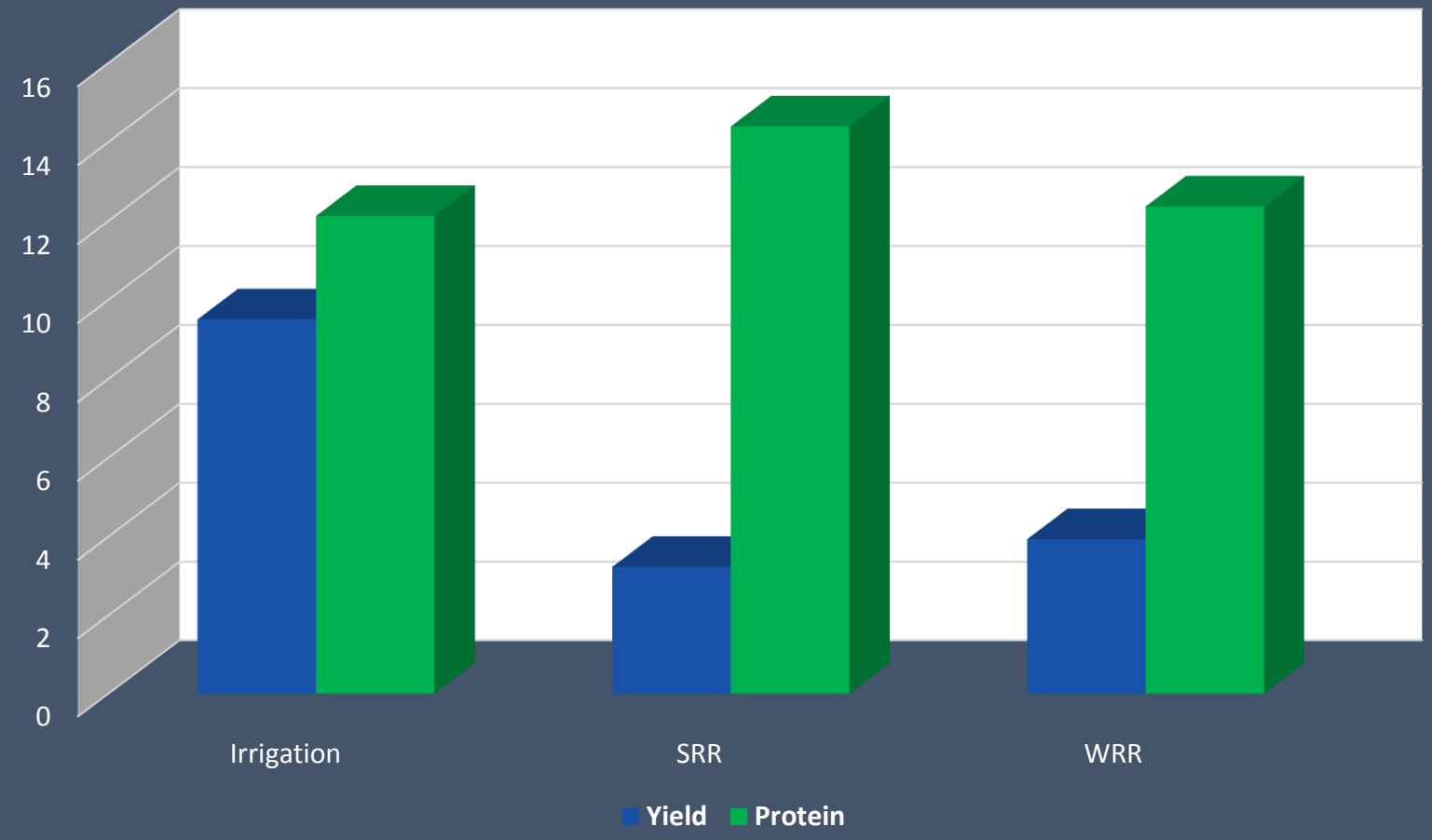
Variation in protein fractions influenced by both genotype and environment but it varied

ANOVA

In the winter rainfall area genotype made large contribution to variation in yield and protein content

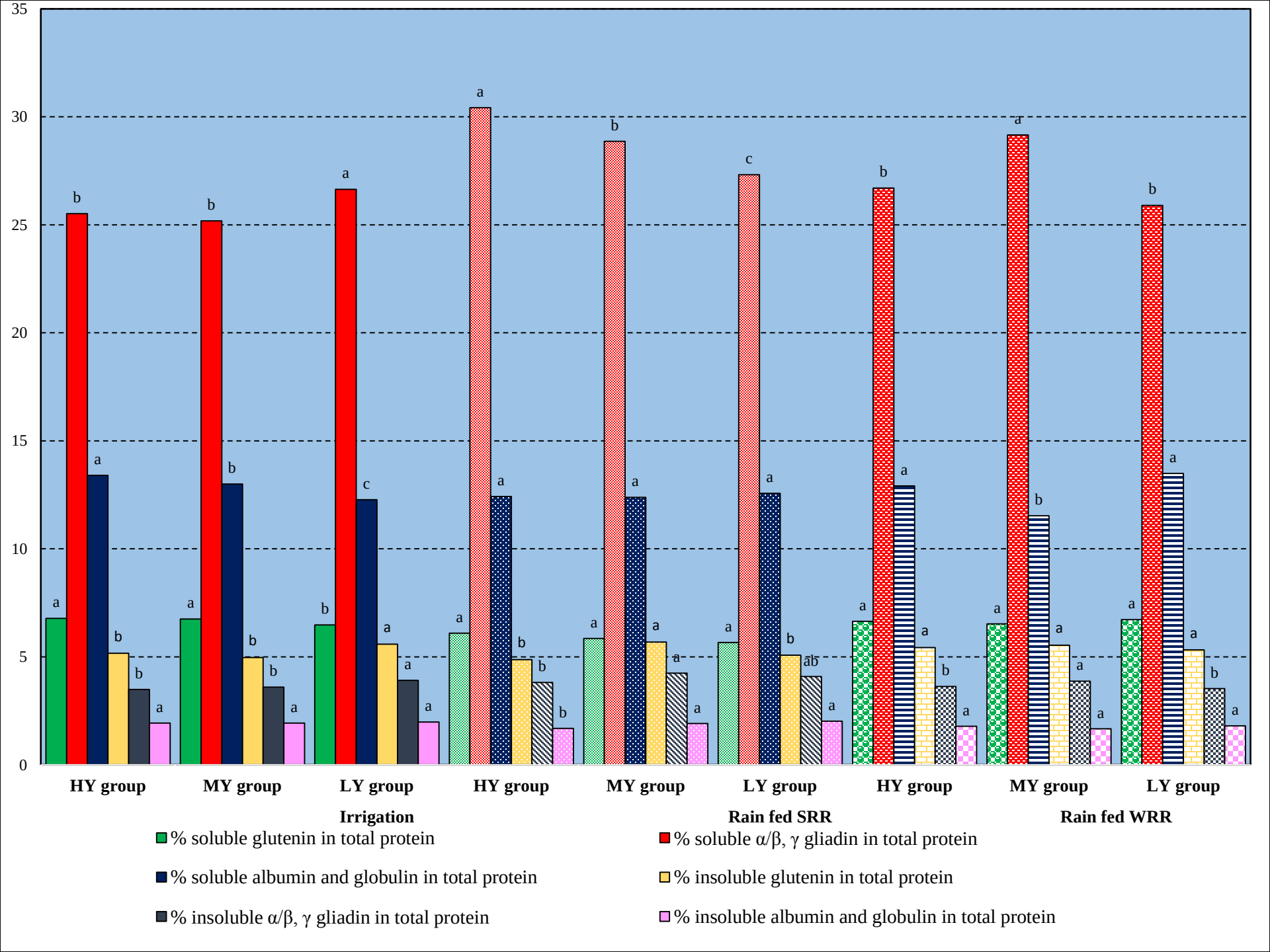
Grain protein showed little GxE interaction, as opposed to grain yield

Yield (ton ha^{-1}) and grain protein content (%) over all cultivars for two seasons for three wheat production regions



Ranking of cultivars in the three production regions for grain yield

Irrigation				Rainfed summer rainfall region				Rainfed winter rainfall region			
Cultivar	Grain yield (ton ha^{-1})	Group	Mean (ton ha^{-1})	Cultivar	Grain yield (ton ha^{-1})	Group	Mean (ton ha^{-1})	Cultivar	Grain yield (ton ha^{-1})	Group	Mean (ton ha^{-1})
PAN 3497	10.84^{a}	High yielding	10.63	SST 316	3.84^{a}	High yielding	3.79	PAN 3471	5.19^{a}	High yielding	5.15
SST 866	10.83^{ab}			SST 317	3.77^{ab}			PAN 3408	5.17^{a}		
Buffels	10.58^{abc}			SST 347	3.75^{ab}			Tankwa	5.17^{a}		
Tamboti	10.53^{abc}							SST 056	5.15^{a}		
PAN 3471	10.50^{abc}							SST 015	5.14^{a}		
SST 876	10.49^{abc}							SST 096	5.14^{a}		
SST 835	10.32^{abcd}	Medium yielding	10.17	PAN 3161	3.66^{abc}	Medium yielding	3.54	SST 027	5.13^{a}		
Krokodil	10.23^{abcde}			Senqu	3.63^{abc}			SST 087	5.09^{a}		
SST 884	10.23^{abcde}			PAN 3368	3.61^{abc}			Ratel	5.01^{ab}	Medium yielding	4.91
SST 806	10.20^{abcde}			Koonap	3.50^{abcd}			SST 047	4.80^{abc}		
PAN 3478	10.18^{bcde}			SST 356	3.45^{abcd}						
PAN 3489	10.04^{cde}			Elands	3.38^{bcde}						
Duzi	9.97^{cde}										
SST 895	9.76^{def}	Low yielding	9.37								
SST 877	9.66^{ef}			PAN 3195	3.27^{cde}	Low yielding	3.14				
Sabie	9.64^{ef}			Gariep	3.17^{de}			SST 88	4.49^{bc}	Low yielding	4.38
SST 822	9.16^{fg}			PAN 3379	2.98^{e}			Kwartel	4.27^{c}		
SST 843	8.62^{g}										


35
30
25
20
15
10
5
0
HY group
MY group
LY group
HY group
MY group
LY group
HY group
MY group
LY group
Irrigation
Rain fed SRR
Rain fed WRR
% soluble glutenin in total protein
% soluble α/β, γ gliadin in total protein
% soluble albumin and globulin in total protein
% insoluble glutenin in total protein
% insoluble α/β, γ gliadin in total protein
% insoluble albumin and globulin in total protein

Correlations

Only significant negative correlation of grain protein with grain yield in the lowest yielding group of irrigation cultivars

($r = -0.60^{**}$)

No other significant correlations

Correlations of protein fractions with grain yield

Solubility	% Protein fractions and ratios	Irrigation		Rainfed summer rainfall region		Rainfed winter rainfall region	
		High yielding	Low yielding	High yielding	Low yielding	High yielding	Low yielding
Soluble fraction in total soluble protein	ω Gliadin (LMP)	NS	NS	NS	NS	0.61**	-0.89*
	α/β, γ Gliadin (LMP)	NS	NS	NS	NS	NS	0.82*
	Albumin/globulin (SMP)	NS	0.54***	0.70*	NS	-0.55**	NS
Insoluble fraction in total insoluble protein	Glutenin (LPP)						
	Glutenin (SPP)	NS	NS	NS	NS	NS	0.83*
	ω Gliadin (LMP)	NS	NS	NS	NS	0.64***	NS
	Albumin/globulin (SMP)	NS	NS	NS	NS	NS	-0.86*
Soluble fraction in total protein	Glutenin (SPP)	NS	0.60***	NS	NS	NS	NS
	ω Gliadin (LMP)	NS	NS	NS	NS	0.71***	-0.89*
	Albumin/globulin (SMP)	NS	0.70***	NS	NS	-0.46*	NS
Insoluble fraction in total protein	Glutenin (LPP)	NS	-0.62***	NS	NS	NS	NS
	α/β, γ Gliadin (LMP)	NS	-0.48***	NS	NS	-0.48*	0.87*
Insoluble fraction in total same fraction	Glutenin (LPP)	NS	-0.61***	NS	NS	NS	NS
	Glutenin (SPP)	NS	-0.51***	NS	NS	NS	NS
	ω Gliadin (LMP)	NS	NS	NS	NS	-0.45*	0.86*
	Albumin/globulin (SMP)	NS	-0.50***	NS	NS	NS	NS
Insoluble glutenin in total glutenin		NS	-0.56***	NS	NS	NS	NS

Results

The concentration of glutenin at harvest was not affected by variations in total quantity of nitrogen per grain

Concentration of gliadin was positively correlated with total quantity of nitrogen per grain

Albumins/globulins decreased with an increase in nitrogen per grain

DISCUSSION AND CONCLUSIONS

Discussion and conclusions

All protein fractions calculated as percentage of total protein were significantly influenced by the environment in irrigation region

In the other two regions genotype and GxE also affected variation in these fractions

ω-Gliadin showed high cross-over interaction in the winter rainfall area

Discussion and conclusions

Soluble α, β and γ gliadin made up the largest percentage in total protein and albumin/globulin the smallest part

In the irrigation region there were a number of correlations between yield and fractions, but only in low yielding group

Overall, for high yielding cultivars, only significant correlations of fractions with yield was in WRR

Discussion and conclusions

Magnitude of correlations of yield with protein fractions were very different between low and high yielding cultivars in WRR

In SRR, which is a low input system, only significant correlation with yield was albumin/globulin fraction

Conclusions

There was no clear negative trend between yield and protein content in the tested cultivars in the three production regions

No definite trends could be seen in the relationship between protein fractions and yield in the cultivars developed for the three production regions

It would seem that genotype and production region strongly influenced the relationship between yield and protein content and composition

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