

Barley cultivar mixtures in theory and practice

A.C. Newton¹, J.S. Swanston¹, G.S. Begg², J.W. McNicol² and S. Hoad³

¹ Scottish Crop Research Institute, Invergowrie, Dundee DD2 5DA, Scotland, UK. Email: a.newton@scri.sari.ac.uk
² Biomathematics and Statistics Scotland, SCRI, Invergowrie, Dundee DD2 5DA, Scotland, UK
³ Scottish Agricultural Colleges, West Mains Road, Edinburgh, Scotland, UK



Compared with the mean of the component monocultures, cultivar mixtures normally:

- 1 Reduce disease
- 2 Increase yield
- 3 Greater yield stability
- 4 Can have similar or superior 'quality'

Definitions:

Two, three or more varieties
 Equal proportions
 Agronomically similar
 Contrasting disease resistance

Questions:

What is the optimum?
 What proportions should be used?
 Complementary more important?
 Quantitative and qualitative resistance?

Mechanisms

Pathology:

Dilution of susceptible varieties (spatial)
 Barrier effect of resistant varieties (spatial)
 Induced resistance (biochemical)

Yield & quality:

Better resource exploitation in:
 Roots
 Canopy

Manipulation

Canopy structure: (morphology)

Architecture
 Geometry

Complexity:

Spatial deployment
 Component number

Factors

Pathology:

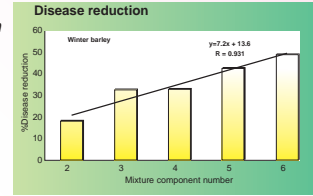
Pathogen
 Pathogenicity mode
 Dispersal characteristics
 Inoculum pressure

Agronomy:

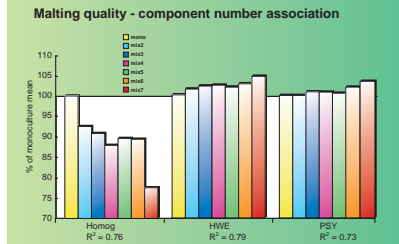
Soil fertility
 Weather

Control of *Rhynchosporium secalis* in complex barley mixtures

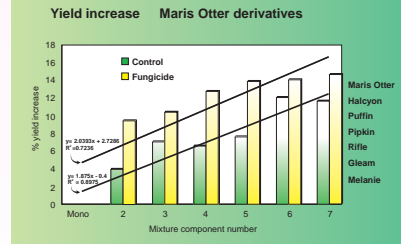
Disease control is proportional to component number



Effects of mixtures on yield and malting quality in complex barley mixtures

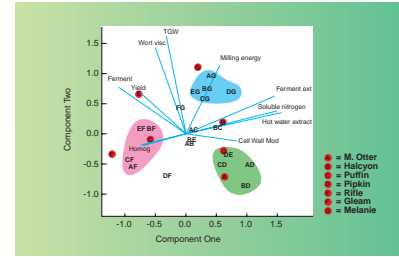


Quality may even increase in mixture



Up to 15% yield increase with complex mixtures

Analysis of the contribution of mixtures components to malting quality



Biplots show groupings with different quality and yield compromises

The methodology will be applied to disease progress data to optimise control strategies

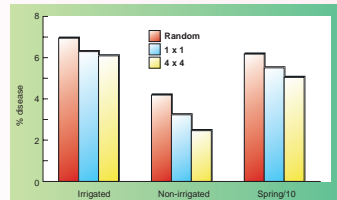
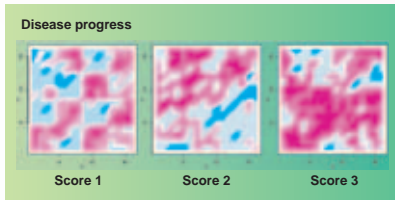
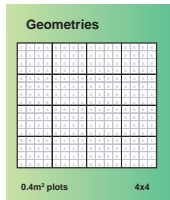
1. Homog	2. 2-component	3. 3-component	4. 4-component	5. 5-component	6. 6-component	7. 7-component
TGW	131.99	131.99	131.99	131.99	131.99	131.99
Milling Energy	10.71	10.71	10.71	10.71	10.71	10.71
Homogeneity	14.88	14.88	14.88	14.88	14.88	14.88
Hot Water Extract	27.49	27.49	27.49	27.49	27.49	27.49
Fermentability	14.88	14.88	14.88	14.88	14.88	14.88
Fermentable Extract	15.44	15.44	15.44	15.44	15.44	15.44
Wort Viscosity	4.23	4.23	4.23	4.23	4.23	4.23
Soluble Nitrogen %	16.69	16.69	16.69	16.69	16.69	16.69
Cell Wall Modification	4.14	4.14	4.14	4.14	4.14	4.14
Yield	15.65	15.65	15.65	15.65	15.65	15.65

Percentage variance accounted for shows individual components of mixtures dominate for particular characters

Effects of spatial deployment patterns

Spatial deployment patterns can be optimised for pathogen dispersal characteristics

Rhynchosporium secalis



Mechanism - Splash distance

Homogeneous mix: A-B-A-B-A-B-A-B: overlapping foliage
 Continuous foliage transmission
 1 x 1 regular mix: A-B-A-B-A-B-A-B: only 0.4 m separation
 Continuous splash transmission
 4 x 4 regular mix: A-B-B-B-A-A-A-A-B-B: 1.6 m separation
 Discontinuous transmission

Structuring resistance gene deployment

Blocks	Homogeneous	Structured
A	ABCDWXYZ	D XYZ
B	ABCDWXYZ	W ABC
C	ABCDWXYZ	ACD B
D	ABCDWXYZ	Y WXY
W	ABCDWXYZ	WXZ Z
X	ABCDWXYZ	A ABD
Y	ABCDWXYZ	BCD X
Z	ABCDWXYZ	WYZ C

Disease	Mean percentage infection	LSD
Solid Mildew	14.1	5.1
	12.9	8.0
	5.1	5.2
	12.0	3.0

Effect of height on pathogen dispersal

All monocultures, 2-, 3- and 4-component equal proportion mixtures of: tall (T), semi-prostrate (S), erectoides (E) and double-dwarf (D) doubled-haploid lines from a cross between Derkado and a breeding line B83-12/21/5 with otherwise near-isogenic *R. secalis* resistance (P12M16h and E32M34a SSR markers):

Line	Height	sdw1(S)	arf-eGP(E)	P12M16h	E32M34a	Rhyn in field
119/1	T	<u>b</u>	<u>a</u>	<u>b</u>	<u>a</u>	3%
127/1	S	a	a	b	a	30%
152/1	E	<u>b</u>	b	<u>b</u>	<u>a</u>	6%
44/1	D	a	b	<u>b</u>	<u>a</u>	17%

a = from Derkado, b = from B83-12/21/5. Underlined = resistant allele

Mixtures with Tall and Double-dwarf cultivars have greater *Rhynchosporium* reduction

Double-dwarf cultivars particularly effective, probably due to greater distance for splash dispersal onto taller cultivars (escape).

Mixtures in 2001 with:	Tall	Semi-prostrate	Erectoides	Double-dwarf
<80% of monoculture mean	4	3	3	6
>80% of monoculture mean	3	4	4	1

Mixtures in 2000 with:	Tall	Semi-prostrate	Erectoides	Double-dwarf
< monoculture mean	4	3	4	5
≥ monoculture mean	3	4	3	2

Mixture trial in 2002:	Yield	<i>R. secalis</i>
2-component	6.9%***	-14% ^{ns}
3- and 4-component	9.9%***	-10% ^{ns}

Conclusions

- Disease control may not be the most important feature of mixtures
- Mixtures can not only give satisfactory quality, but there is scope to exceed that of its components
- Spatial deployment in mixtures can be optimised for pathogen populations and dispersal characteristics
- Component varieties may behave differently in simple and complex mixtures

Acknowledgements

We thank David Guy, Andy Wilson, Bill Thomas, Dave Pugh, Euan Caldwell, Alan Young, Roger Ellis, Christine Hackett, Alice Bertie for helping with various aspects of the work, the Scottish Executive Environment and Rural Affairs Department and the Scottish Society for Crop Research for funding. Web information on mixtures can be found at: www.scri.sari.ac.uk/tpp/mix