Barley cultivar mixtures in theory and practice

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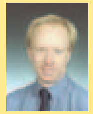


Compared with the mean of the component monocultures, cultivar mixtures normally:

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

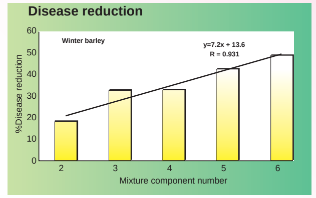
Definitions:
Two, three or more varieties
Equal proportions
Agronomically similar
Contrasting disease resistance

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

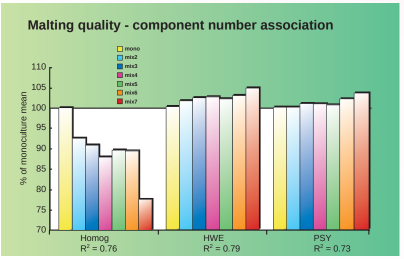
Mechanisms	Manipulation	Factors
Pathology : Dilution of susceptible varieties (spatial); Barrier effect of resistant varieties (spatial); Induced resistance (biochemical)	**Canopy structure : (morphology)** Architecture; Geometry	**Pathology :** Pathogen; Pathogenicity mode; Dispersal characteristics; Inoculum pressure
Yield & quality : Better resource exploitation in: Roots; Canopy	**Complexity :** Spatial deployment; Component number	**Agronomy :** Soil fertility; Weather

Control of *Rhynchosporium secalis* in complex barley mixtures

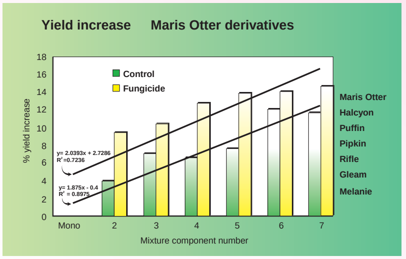
Disease control is proportional to component number



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

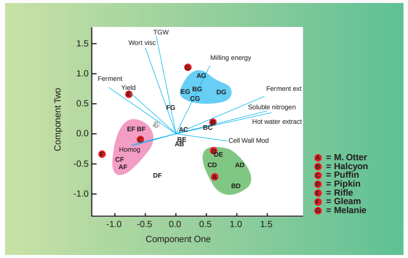


Quality may even increase in mixture



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

1 term <0.05	Halcyon B	Puffin C	Pipkin D	Rifle E	Gleam F	Melanie G
2-component						
TGW			-31.99		-4.64	+27.13
Milling Energy		-10.71				+11.6
Homogeneity						-6.25
Hot Water Extract			+14.88		-38.55	-6.94
Fermentability		+6.16	-27.49			
Fermentable Extract			+5.44		-37.24	+10.79
Wort Viscocity			-4.23			+4.41
Soluble Nitrogen %			+6.69		-33.71	+6.19
Cell Wall Modification					-4.14	
Yield					+15.65	+9.21

1 term <0.05	B	C	D	E	F	G
5-component						
TGW			-31.75			+17.1
Milling Energy						+8.35
Homogeneity						
Hot Water Extract	+3.5		+15.1		-26.4	
Fermentability						
Fermentable Extract			+8.71		-21.37	
Wort Viscocity						
Soluble Nitrogen %			+3.54		-7.88	
Cell Wall Modification					-6.31	
Yield						

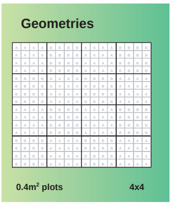
Percentage variance accounted for shows individual components of mixtures dominate for particular characters

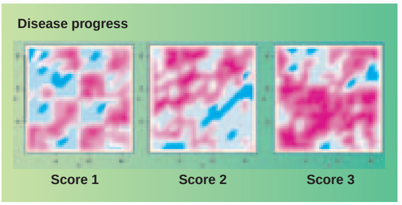
The methodology will be applied to disease progress data to optimise control strategies

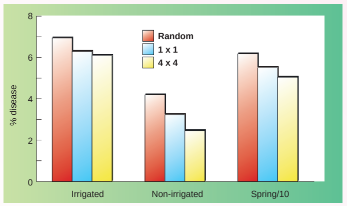
Effects of spatial deployment patterns

Spatial deployment patterns can be optimised for pathogen dispersal characteristics

Rhynchosporium secalis







Mechanism – Splash distance

Homogeneous mix:
ABABABABABABABA: 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—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	Blocks	Homogeneous (Mean percentage infection)	Structured	LSD
Scald	14.1	5.1	5.1	5.2
Mildew	12.9	12.0	8.0	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) (3)562	ari-eGP(E) (5)349	P12M16h (7)68	E32M34a (2)53	Rhyn in field
119/1	T	b	a	b	a	3%
127/1	S	a	a	b	a	30%
152/1	E	b	b	b	a	6%
44/1	D	a	b	b	a	17%

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

	Tall	Semi-prostrate	Erectoides	Double-dwarf
Mixtures in 2001 with:				
<80% of monoculture mean	4	3	3	6
>80% of monoculture mean	3	4	4	1
Mixtures in 2000 with:				
< monoculture mean	4	3	4	5
≥ monoculture mean	3	4	3	2

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).

Mixture trial in 2002:	Yield	*R. secalis*
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

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