Deployment of disease resistance in barley: theoretical expectations and interactions with cultivation methods

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Background

Many modern crop cultivars are bred for high input systems and grown as monocultures.

Plant genetic traits that allow crops to perform well under minimum/zero tillage need to be identified to assist with developing new varieties.

Genetic diversity of mixed cultivars grown together may decrease the impact of disease and maintain yield and quality despite variable climatic and soil conditions.

Modelling may help determine how to optimise mixtures design for best disease reduction and avoidance of super-aggressive races.

Field Experiment

Five tillage systems employed to manipulate the soil physical environment:

(1) zero-tillage;
(2) minimum tillage;
(3) conventional ploughing to 20 cm;
(4) conventional ploughing to 20 cm and compaction by wheeling of the entire plot; and
(5) deep ploughing to 40 cm depth.

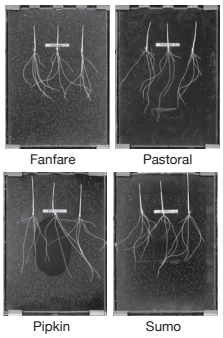
Experiment commenced in autumn 2003 and is on-going.

Selecting Mixtures

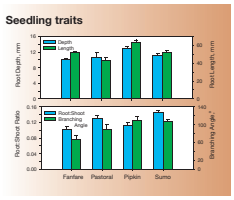
A screen of winter barley cultivars selected four varieties with contrasting root traits and pathogen resistance.

National List attributes identified cultivars for further screening in the laboratory.

Root gel chambers allowed root branching angle, length and depth to be measured on 10 day old seedlings.



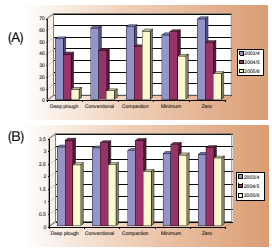
Seedling roots varied significantly in length***, angle** and root:shoot ratio** between cultivars.



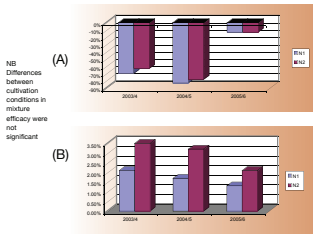
$^{***}P<0.001$; $^{**}P<0.01$

Trial Results

Effect of cultivation on Area Under the Disease Progress Curve (AUDPC) (A) and yield (B).

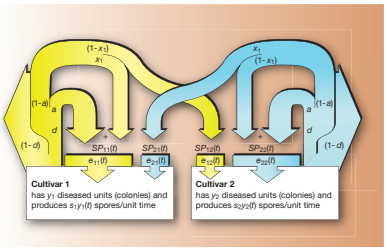


Effect of mixtures compared with the mean of their monoculture. components on AUDPC (A) and yield (B) at two fertiliser levels.



Modelling

Flow diagram for the production, dispersion and deposition of spores from and on to a mixture of two cultivars. Pathogen increases its infection efficiency when it auto deposits back to the cultivar from which it is produced and decreases its infection efficiency when it re-deposits to another cultivar.



Mixture of cultivars in any proportions tends to reduce the aggressiveness of pathogens at equilibrium but this effect decreases either when two mixture components are in extremely unbalance or are in closed proportions.

The evolutionary rates of aggressiveness and its value at equilibrium increase as auto-deposition rates increase.

The relative levels of initial resistances in mixture components do not have impacts on the aggressiveness of pathogens at equilibrium, but strongly influence transient values of the aggressiveness.

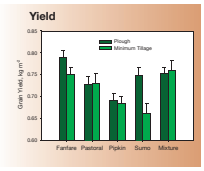
The rates between the cost of re-deposition and the benefit of auto-deposition did not affect the final outcome of aggressiveness but did affect the time of reaching its equilibrium.

Cultivars and Mixtures

Grain yield affected significantly by tillage and cultivar.***

Mixtures outperformed average yield of all monocultures.**

Note – data collected in first year of experiment.



Conclusions

Impact of tillage on crop performance is cultivar dependent.

Mixtures maintain or improve yield and may reduce the impact of variable climatic or soil conditions.

Genetic traits beneficial for crop performance in low input tillage will be studied using root mutants from SCRI's barley mapping population.

Mixing 75% resistant cultivar and 25% susceptible cultivar could achieve the best effect in slowing down the evolution of pathogens.

Acknowledgements

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