

# Selecting rape (*B. napus*) and turnip (*B. rapa*) lines for biofumigation potential

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## Summary

A range of rape (*Brassica napus*) and turnip (*Brassica rapa*) lines from a forage brassica breeding programme were tested for their biofumigation potential. Lines initially screened for glucosinolates were chosen because they were considered palatable or unpalatable by grazing animals. A forage rape and a leafy turnip were selected to form a biofumigant mixture. Reselections of related lines improved the levels and types of GLCs present in the plants. Crosses were made with the selected lines to produce breeding material for further selection.

## Preliminary screening to identify promising lines

Forage brassicas breeders have long been interested in glucosinolates (GLCs) and isothiocyanates (ITCs) because of their effect on plant acceptability for animals (Figure 1).



Figure 1 Differences in forage rape lines in their acceptability to sheep.

Whereas low levels of GLCs are wanted for forage purposes, high levels of GLCs are needed for biofumigation. The GLCs wanted for biofumigation are those that release volatile, toxic ITCs, and these are also thought to be responsible for poor acceptability. An initial screening was made to examine the GLC levels of various forage brassicas considered to be of high or low preference to sheep (Figure 2).

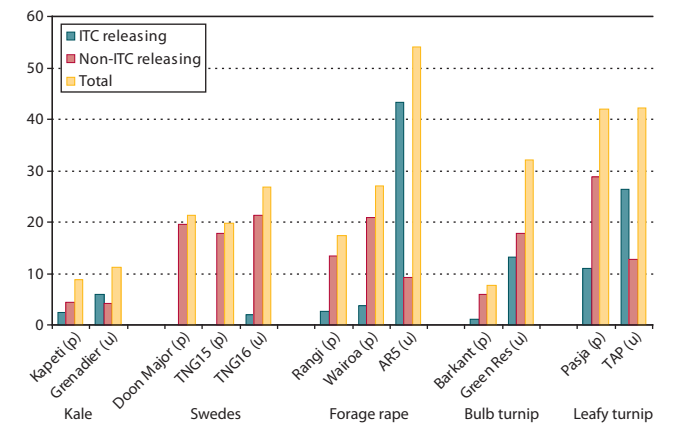


Figure 2 Glucosinolate content (µmol/g) of leaves of various brassicas types considered to be palatable (p) or unpalatable (u) to sheep<sup>1</sup>.

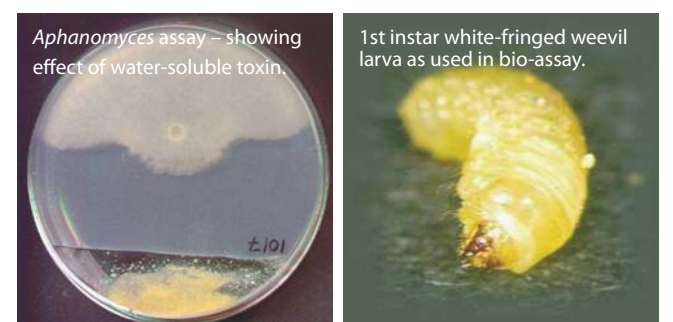
AR5 rape and leafy turnip TAP were the two best lines for biofumigation. Leafy turnip Pasja had the same total level of GLCs as TAP, but most of the GLCs present in TAP were ITC-releasing ones, whereas those of Pasja were not. AR5 and TAP were released as a biofumigant mixture called BQMulch by Wrightsons Seeds.

## Further selection for biofumigation potential

The next stage was to examine lines similar to AR5 and TAP to see if any were potentially better for biofumigation.

To help identify better lines, bioassays were developed and gas chromatography (GC) was used to analyse ITC release from plant material. CSIRO Entomology developed the GC technique<sup>2</sup> and a bioassay using white-fringed weevils (WFW, *Graphognathus leucoloma*)<sup>3</sup> while Wrightsons Research/Crop & Food Research developed a fungal assay using pea root rot (*Aphanomyces euteiches*).

Initial studies of ITC levels in soil after incorporation of rape showed 2-phenylethyl (2PE) ITC had the highest levels, with only small amounts of others<sup>4</sup>. Rapes appear to have relatively high levels of 2PE, although it is in the roots and not in stems or leaves. AR5 had high levels of other GLCs, but its 2PE levels were



unusually low. Screening related lines produced reselections (ARX lines in Figure 3 & Figure 4) which combined high general levels of ITCs with high levels of 2PE, and/or high levels of kill with *Aphanomyces* and WFW assays.

## Crossing and selection to generate advanced breeding lines

Further work involved crossing AR5 with commercial cultivars and other breeding lines to increase levels of ITC released and bioassay action. The best lines produced were the B1 series shown in Figures 3 & 4. Higher levels of 2PE ITC were obtained, along with small increases in the other ITCs, to give greater total levels of ITCs. Effects on WFW were generally better, with 25 g samples producing 100% kill in some cases, compared to 50 g samples needed with the AR lines.

Although root samples of B1 lines of rape give high levels of ITC release and WFW kill, the leaves and stems have relatively little

effect. Root tissue is difficult to break down and incorporate in soil, whereas leaf and stem can be macerated and incorporated more easily. Rape roots may not have a rapid release of ITCs, but they have a more gradual and lasting effect.

Leafy turnips, in comparison, are easy to incorporate. To improve the initial impact on incorporation of the BQ Mulch mixture, work has also been carried out to improve the leafy turnip component. Some improvements have been made, with the most successful lines being obtained from cv. Perko x cv. Appin, the reciprocal cross of TAP.

## Discussion

- Although there are correlations between ITC release and bioassay results, data are inconsistent (e.g. line B1.83.6 in Figure 3).
- A major problem is the role of 2PE in biofumigation, and in particular in assays that rely on the release of gases. Although most ITCs are gaseous, 2PE has a very low vapour pressure (virtually zero) so should not be released as a gas.
- Another problem has been variation in ITC production from plants grown in different seasons and different fields.

- The most important aspect, however, is the overall suitability of rape and turnips for biofumigation. The WA work on mulching<sup>5</sup> gives much improved incorporation of ITCs in the soil, such that high levels of 2-propenyl ITC can be obtained. This ITC is not usually present in rape and turnips. It may be that mustard is better for biofumigation because it contains large quantities of 2-propenyl ITC. The spectrum of ITCs from rape and turnips may give better control of some pests and diseases, but this remains to be seen.

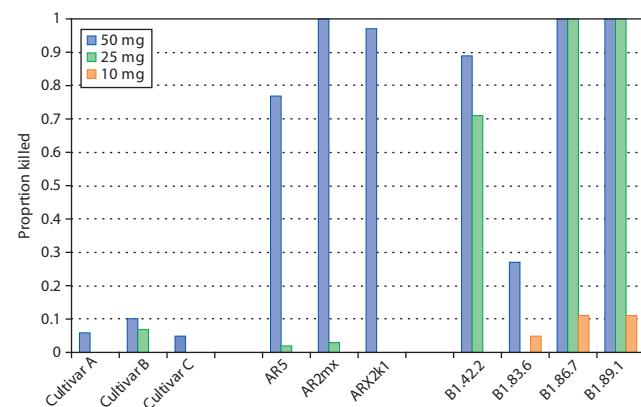


Figure 3 WFW mortality in assays with cultivars and selections of rape using 10, 25 and 50 mg samples of tissue.

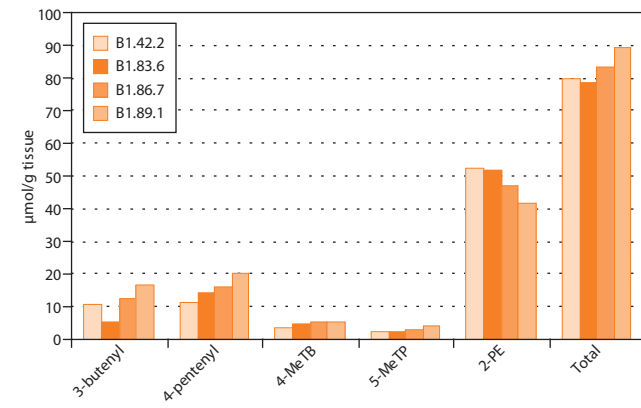
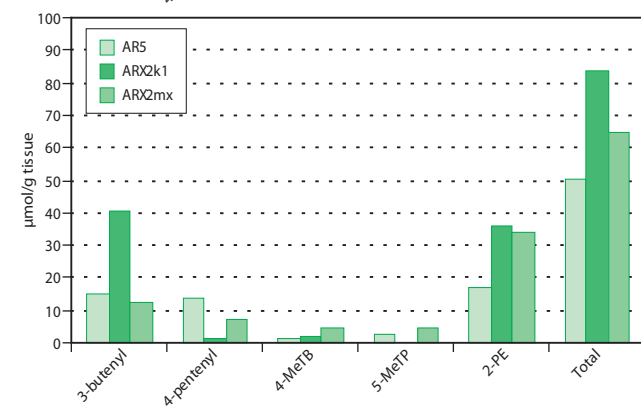
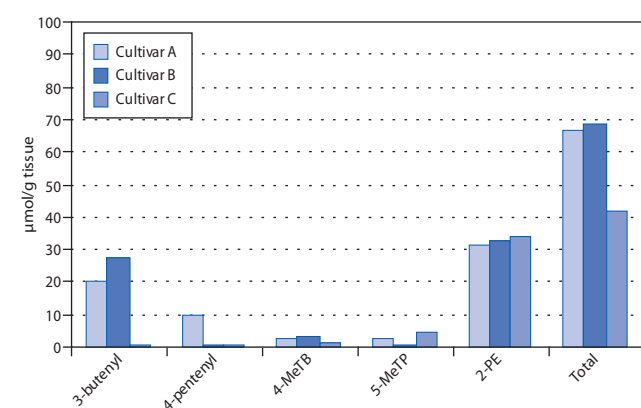


Figure 4 Diagrams to show distribution and levels of main ITCs in root samples of standard cultivars and breeding lines.



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## Acknowledgements

Thanks to -  
John Matthiesen, Mark Shackleton and Ben Warton, CSIRO Entomology, Wembley  
John Kirkegarde and M. Sawar, CSIRO Canberra  
Johanna Steyart and Jenny Sutherland, Wrightson Research.

## References

1. Sawar M, J Kirkegaard, S Gowers, BJ Garrett. Cruciferae Newsletter 19, 1997.
2. Warton B, JN Matthiesson and MA Shackleton. J Agric Food Chem. 49, 2001.
3. Matthiesson JN, JM Desmarchelier, LT Vu and MA Shackleton, J Econ. Entomol. 89, 1996.
4. Gardiner JB, MJ Mora, CV Eberlain, PD Brown and V. Borek. J Agric. Food Chem 47, 1999.
5. Matthiesson JN, B Warton, and MA Shackleton. Agroindustria 3, 2004.