



A Comparison of the Quality of Oil & Meal from Winter Oilseed Rape Grown under Different Management Practices

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Introduction

A long term integrated cropping system - The Centre for Sustainable Cropping (CSC; <http://csc.hutton.ac.uk/>) was established at Balruddery Farm, Dundee in 2009 by the James Hutton Institute, to integrate all aspects of moving towards more sustainable arable ecosystems, & to quantify both the environmental & economic costs, & benefits of integrated management crop production.

Over the course of the six year rotation, the aim was to optimise inputs (nutrients, herbicides & pesticides), yield, biodiversity & ecosystem processes. The rotation was representative of commercial practices, & used six different crops - potato, Winter wheat, Winter & Spring barley, field beans & Winter oilseed rape (WOSR) – all grown due to their economical importance to Scotland.

For each crop, five varieties were grown each year under conventional & integrated management practices. This report investigates whether there will be an impact of the different management practices on the quality of WOSR.

The varieties used in this study were all low erucic acid varieties that produce oils for uses in food, or for non-food uses such as biodiesel. The rapeseed meal remaining after oil extraction can be used as a high protein animal feed.

The oil content, fatty acid & tocopherol compositions of the oil were determined. The residual meal was analysed for total Carbon (% C), Nitrogen (% N), phytic acid & glucosinolate content - the latter two considered anti-nutrients.

Methods

Cultivation

- The plants from five WOSR varieties were grown in strips in two half fields; in one half they were grown conventionally (Con) & in the other an integrated (Int) management system was used.
- WOSR was grown over six years (2011-2016). The varieties Catana & Excalibur were grown in each of the six years, whereas Cracker (2014-2016), Flash (2012-2014), Lioness (2011-2013) & NK Grace (2011-2013) were each grown only in three years.
- The 'Con' management practice were typical of current commercial practice & included application of inorganic fertilizer, herbicides, pesticides & fungicides. The 'Int' management practice involved reduced pesticide inputs using integrated pest management strategies, reduced inorganic fertilizer inputs by utilising compost, legumes, green & precision farming, & improved soil structure through reduced tillage & traffic. Each year, each variety strip (under both Con & Int) was harvested, & five hand-sampled replicates of WOSR seeds removed for analyses.

Analytical Methodology

- Oils were extracted using Soxhlet extraction with isohexane, & oil content was expressed as a weight percentage (wt %) of the seed mass.
- Fatty acid methyl esters (FAME), released from oils using sodium methoxide transesterification, were analysed by Gas Chromatography (GC) on a CPWax-52CB column, & individual FAME were expressed as a wt % of total FAME, & as mg per g of oil.
- Tocopherol composition of the oil (mg kg^{-1}) was determined by High Performance Liquid Chromatography (HPLC) on a Lichrosorb Si60-5 column with fluorescence detection.
- Glucosinolates ($\mu\text{moles g}^{-1}$), extracted from rapeseed meal, were analysed by Liquid Chromatography-Mass Spectrometry (LC-MS) on a Luna C18-RP column using negative electrospray ionisation.
- Extracted phytic acid (mg g^{-1}) was measured using Wade reagent & UV spectrophotometry.
- Total % C & % N (the latter converted to total protein by * 6.25) were determined by Elemental Analysis.

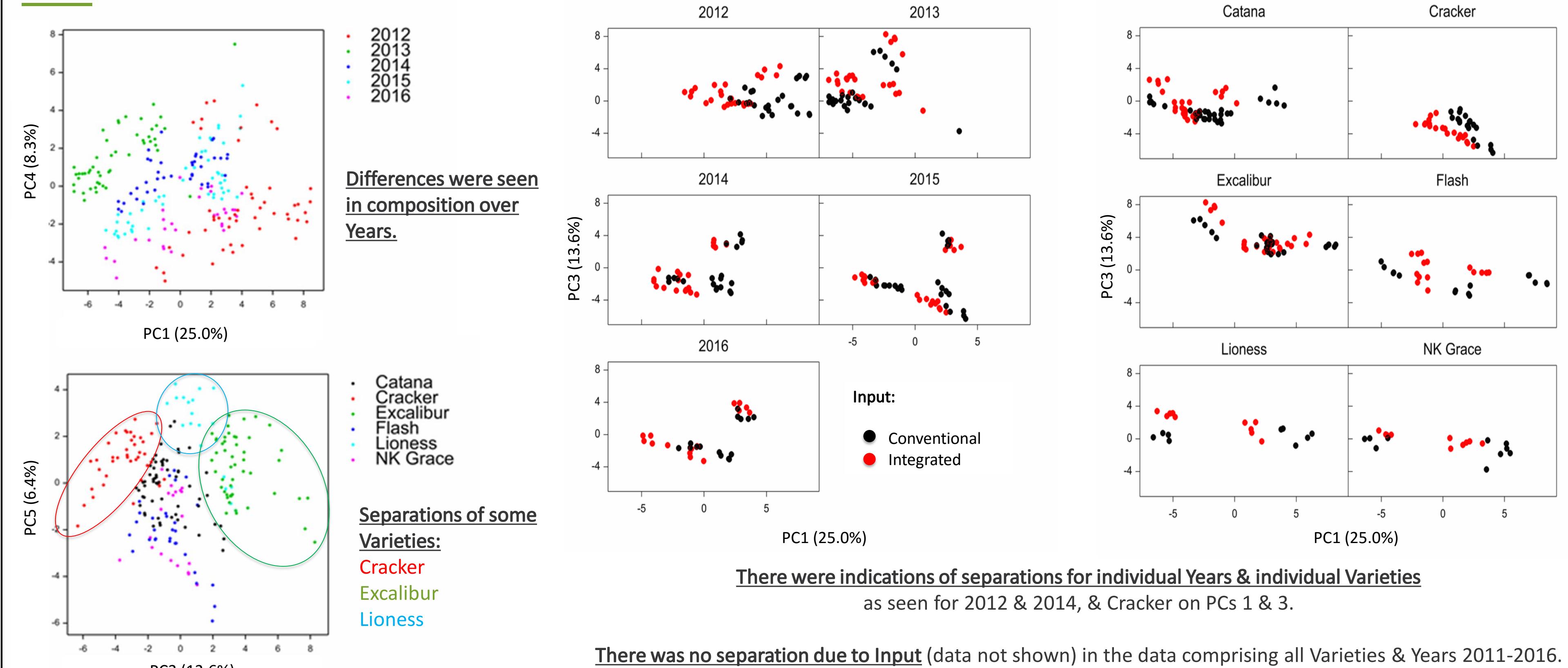
Statistical Analyses

- Broad scale variation in the metabolites were analysed using Principal Components Analysis (PCA), using GenStat for Windows 18th edition. Plots of component (PC) scores were examined for association of PCs with Variety, Input (management practice) & Year.
- Each compound was also analysed individually (\log_{10} scale) using a Restricted Maximum Likelihood (REML) model, to test for significant effects of Variety, Input, Year or an Interaction of these terms.

Results

Data, comprising a total of 55 variables (20 fatty acids as wt % & mg g^{-1} oil, % oil, % C, total protein, phytic acid content, α -, γ -, & δ -tocopherol (& total tocopherol content), six individual & total glucosinolates content), were analysed by PCA. In 2011 only fatty acids & % oil were measured, & therefore PCA analysis only used data from Years 2012-2016 (i.e. 2011 data was excluded). All Years were included in the REML analysis.

PCA



REML

REML revealed significant differences in many metabolites among varieties. The most important are shown below, but the differences in magnitude are not large.

Metabolite	Variety means back-transformed to natural scale						
	Catana	Cracker	Excalibur	Flash	Lioness	NK Grace	Sig
Total tocopherols (mg kg^{-1})	542.34	619.54	575.85	578.01	507.97	526.33	***
Phytic acid (mg g^{-1})	61.72	53.71	59.04	59.12	58.66	61.13	**
Total glucosinolates ($\mu\text{mol g}^{-1}$)	31.67	24.34	42.23	33.15	31.43	29.63	**
α :16:0 (%)	4.22	4.58	4.84	4.53	4.12	4.39	**
α :18:0 (%)	1.60	1.65	1.71	1.49	1.64	1.40	**
18:2(0:6) (%)	17.70	19.26	20.73	19.54	16.55	18.34	**
18:1(0:9) (%)	60.26	57.68	56.97	57.11	62.74	58.41	*
Oil content (%)	43.73	41.76	41.57	42.61	42.19	41.27	*

Significant differences due to Input were seen in only a few metabolites. However the significance level was low & the differences small.

Metabolite	Variety means back-transformed to natural scale		
	Con	Int	Sig
α :20:0 (%)	0.59	0.58	*
α :22:0 (%)	0.36	0.34	*
Phytic acid (mg g^{-1})	56.56	61.22	*
Total tocopherols (mg kg^{-1})	572.45	543.01	*

Acknowledgements

Special thanks to Cathy Hawes (site manager), Euan Caldwell (farm manager), David Young (crop management), Stuart Wale & Andy Steven (agronomy), Mark Young (data archiving), Gill Banks, Paul Neave & Linda Nell (field surveys).

This work funded under the Strategic Partnership Programme of The Scottish Government Rural & Environmental Science & Analytical Services (RESAS) division.

Conclusions

- PCA & REML analyses of six consecutive Years' data revealed many significant differences in rapeseed composition due to Year & Variety, but the changes were not large.
- Differences according to Input were not evident by PCA over all Years & Varieties, but there were indications of differences within some individual Years or Varieties.
- REML analysis revealed small significant differences due to Input in a few metabolites.
- The evidence suggests that our integrated management system has only slight effects on the quality of rapeseed grown, when compared with the conventional management system used in this study.

