Comparison of Rapeseed Grown Sustainably and Conventionally

A Comparison of the Quality of Oil and Meal from Winter Oilseed Rape Grown under Sustainable and Conventional Cultivation Practices

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Introduction

The Centre for Sustainable Cropping (CSC) is a long term sustainable cropping system established at Balruddery Farm at the James Hutton Institute in 2009 to integrate all aspects of sustainability in arable ecosystems, and to quantify the environmental and economic costs and benefits of sustainable crop production. Over the course of a 6 year rotation the aim is to optimise inputs (nutrients, herbicides and pesticides), yield, biodiversity and ecosystem processes. The 6 year rotation is representative of commercial practices and uses 6 different crops (potato, winter wheat, winter and spring barley, field beans and winter oilseed rape) commonly grown in Scotland. For each crop, 5 varieties are grown under conventional and sustainable (low input) cultivation practices.

This report is concerned with the impact of the different cultivation practices on the quality of winter oilseed rape. The varieties used in this study are all low erucic acid varieties that can be used to produce oils for uses in food, or for non-food uses (e.g. biodiesel). The rapeseed meal remaining after oil extraction can be used as a high protein animal feed.

The oil content, and fatty acid and tocopherol compositions of the oil were determined together with the C, H, N and phytic acid (an antinutritional compound) contents of the meal. The data from the first four years (2011-2014) of the rotation are presented.

Methods

Cultivation

The plants from five winter oilseed rape cultivars were grown in strips in 2 half fields; in one half they were grown conventionally and in the other sustainably. Oilseed rape was grown in rotation over 4 years (2011-2014) with potato, winter wheat, winter and spring barley and field beans. Cultivars Catana and Excalibur were grown in each of the 4 years, whereas Flash (2012-2014), Lioness (2011-2013) and NK Grace (2011-2013) were grown in 3 years.

Conventional conditions were typical of current commercial practice and included application of inorganic fertilizer, herbicides, pesticides and fungicides. Sustainable conditions involved reduced pesticide inputs using integrated pest management strategies, reduced inorganic fertilizer inputs by utilizing compost, legumes, green and precision farming, and improved soil structure through reduced tillage and traffic.

Following harvest, the seeds from each cultivar grown under each cultivation practice were bulked and five replicates were taken.

Analytical methodology

Oil extraction was carried out by Soxhlet extraction with isohexane, and oil content was expressed as a weight percentage 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 and individual FAME were expressed as a weight percent of total FAME and as mg per g of oil. Tocopherol composition of the oil (mg kg^{-1} oil) was determined by high-performance liquid chromatography (HPLC) on a Lichrosorb Si60-5 column with fluorescence detection. Phytic acid, extracted from rapeseed meal, was measured using Wade reagent and UV spectrophotometry. % C, H and N were determined using an Elemental Analyser.

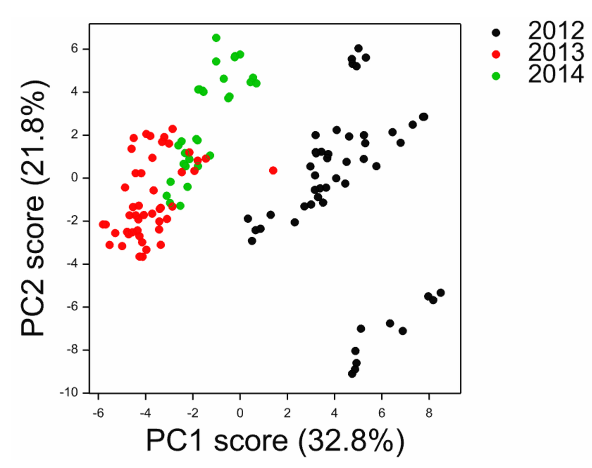
Statistical treatment

To summarise broad scale variation the metabolites were analysed with Principal Components Analysis (PCA) using GenStat 17. Plots of component scores were examined for association of PCs with year, cultivar or cultivation practice.

Results

The data, comprising 49 variables (20 fatty acids as wt % and mg g^{-1} oil, % oil, % C, H and N, phytic acid content and α–, γ–, δ– and total tocopherol content), were analysed by PCA. In 2011 only fatty acids and % oil were measured and therefore this year was excluded from the PCA analysis.

The major difference in composition was among years as seen in the PC1v2 plot.

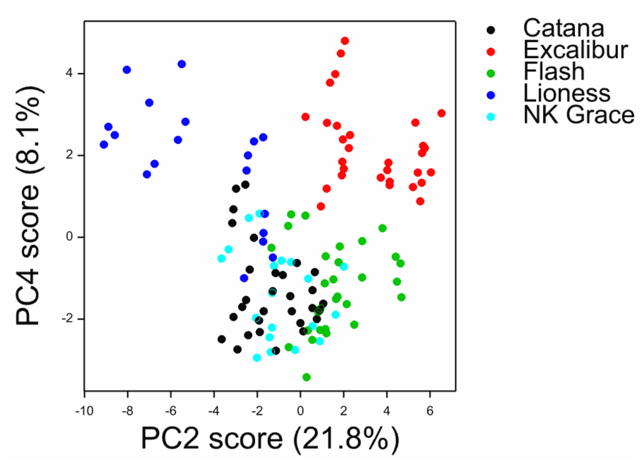


In Table 1 there are 19 components, including minor fatty acids, total C, oil and tocopherols, that showed differences among years.

In Table 1 mean values of all cultivars and both cultivation practices are given.

Compound	2011	2012	2013	2014
14:0%	0.042	0.044	0.054	0.050
14:0 (mg/g)	0.42	0.42	0.52	0.50
18:0%	1.79	1.49	1.58	1.48
18:0 (mg/g)	17.14	13.61	14.69	14.24
20:0%	0.63	0.59	0.55	0.55
20:0 (mg/g)	5.88	5.33	5.03	5.14
22:0%	0.37	0.39	0.30	0.34
22:0 (mg/g)	3.40	3.44	2.71	3.13
16:1(n-9)%	0.045	0.049	0.043	0.039
24:1%	0.20	0.25	0.16	0.20
24:1(mg/g)	1.88	2.19	1.41	1.86
16:3%	0.12	0.14	0.10	0.12
16:3 (mg/g)	1.11	1.27	0.94	1.15
α-toc (mg/kg)		237.5	226.8	185.0
γ-toc (mg/kg)		273.4	331.5	328.4
δ-toc (mg/kg)		15.60	13.92	8.67
Total toc (mg/kg)		527.1	572.7	521.4
Oil content (%)	36.02	41.06	45.12	45.11
Total C (%)		43.86	41.92	42.25

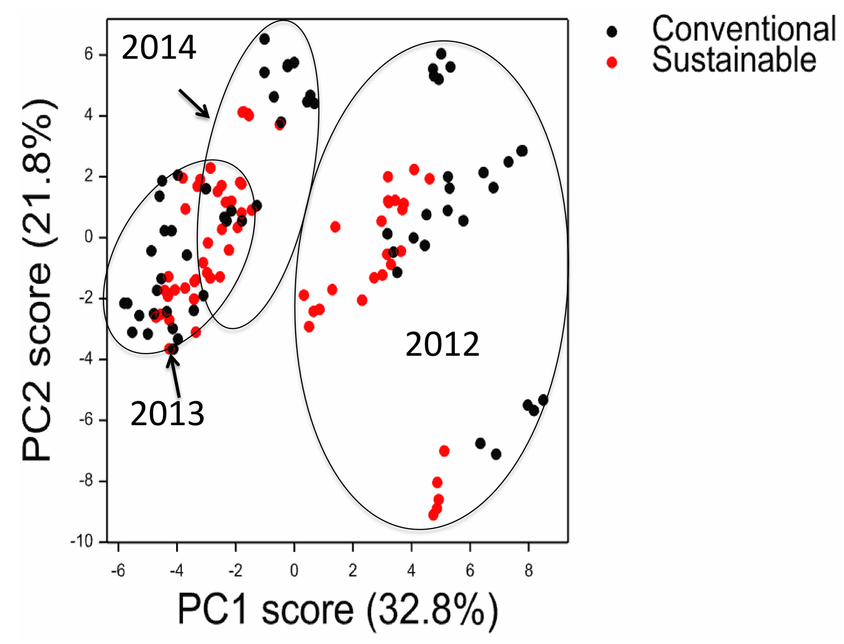
There were also differences among cultivars as seen in the PC2v4 plot. With the exception of Catana and NK Grace, all cultivars could be separated.



In Table 2 there are 25 components, including major fatty acids 16:0, 18:2(*n*-6), minor fatty acids and tocopherols, that showed differences among cultivars. Excalibur had the highest levels of many components.

In Table 2 mean values of all years and both cultivation practices are given.

Compound	Catana	Excalibur	Flash	Lioness	NK Grace
14:0%	0.042	0.055	0.050	0.044	0.047
14:0 (mg/g)	0.41	0.54	0.49	0.43	0.46
16:0%	4.18	4.81	4.50	4.09	4.36
16:0(mg/g)	40.16	46.26	43.21	38.65	42.24
18:0%	1.62	1.72	1.50	1.66	1.42
18:0 (mg/g)	15.29	16.23	14.18	15.35	13.47
20:0%	0.57	0.62	0.56	0.59	0.56
20:0 (mg/g)	5.27	5.72	5.19	5.33	5.20
22:0%	0.32	0.37	0.35	0.34	0.35
22:0 (mg/g)	2.91	3.41	3.20	3.03	3.27
16:1(n-7)%	0.20	0.25	0.24	0.24	0.24
16:1(n-7)(mg/g)	1.90	2.36	2.31	2.21	2.32
17:1%	0.080	0.070	0.076	0.079	0.080
17:1 (mg/g)	0.75	0.66	0.72	0.73	0.76
20:1(n-9)%	1.21	1.23	1.36	1.35	1.25
18:2(n-6)%	17.55	20.62	19.43	16.43	18.22
18:2(n-6)(mg/g)	163.8	192.6	181.3	151.0	171.5
20:2(n-6)%	0.070	0.080	0.077	0.068	0.074
20:2(n-6)(mg/g)	0.64	0.73	0.71	0.61	0.68
16:3%	0.12	0.11	0.13	0.12	0.12
16:3 (mg/g)	1.13	1.07	1.18	1.08	1.10
α-toc (mg/kg)	227.2	224.3	240.6	179.7	209.9
γ-toc (mg/kg)	289.4	334.0	327.2	308.2	294.7
δ-toc (mg/kg)	13.29	12.03	13.15	11.78	12.18
Total toc (mg/kg)	531.3	571.9	583.1	499.3	517.8



PCA shows some slight separation on PC1 of conventional and sustainable samples within years. This PC represents changes in composition of a wide range of components. However this is not consistent over years with scores being greater for sustainable in 2013 and the reverse for 2012 and 2014. This indicates that some variables that tend to be higher or lower in the sustainable samples in 2012 and 2014, tend to behave in the opposite way in 2013.

Conclusions

- Analysis of 4 years data revealed that year to year differences in rapeseed composition were greater than differences due to cultivar or cultivation practice. Many components, for example oil content, varied among years.
- There were also differences due to cultivar. Many components, including major fatty acids 16:0 and 18:2(*n*-6) and tocopherols varied among cultivars suggesting that there are minor differences in the quality of oils from different cultivars.
- There were small differences according to cultivation practice but this was only within individual years. **The evidence so far suggests that cultivation practice has only slight effects on the quality of rapeseed.**
- Data from further years are required in order to establish whether any consistent differences due to cultivation practice emerges.

Acknowledgements

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