Impact of Different Management Practices on Water Soluble Vitamin Content in a Range of Crops

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Introduction

UK(1) & EU(2) agricultural polices & strategies are shifting towards sustainable use of resources & conservation of farmland biodiversity. Clearly, there is a need for balancing environmental management whilst maintaining crop yield & nutritional quality. Water soluble vitamins including B vitamins (B_1 - thiamine, B_2 - riboflavin, B_3 - nicotinic acid, B_5 - pantothenic acid, B_6 - pyridoxine), as well as vitamin C are one important aspect contributing to overall nutritional quality. Vitamins are a broad group of organic bioactive compounds that are minor, but nutritionally essential constituents of food. In 2009, The James Hutton Institute set up the Centre for Sustainable Cropping (CSC) Platform (http://csc.hutton.ac.uk/) as a long-term experimental platform for cross-disciplinary research on sustainability in agricultural ecosystems (Figure 1). The CSC is a 42 hectare contiguous block of six arable fields within the Balruddery Farm, Dundee, North-East Scotland. A method by Nurit et al.(3) was adapted to quantify the levels of five water soluble B vitamins in a range of different crop matrices, including potato, field beans, Spring barley, Winter barley & Winter wheat, to explore whether our integrated management practices impact upon the water-soluble vitamins in these crops in a rotational system over five consecutive years.

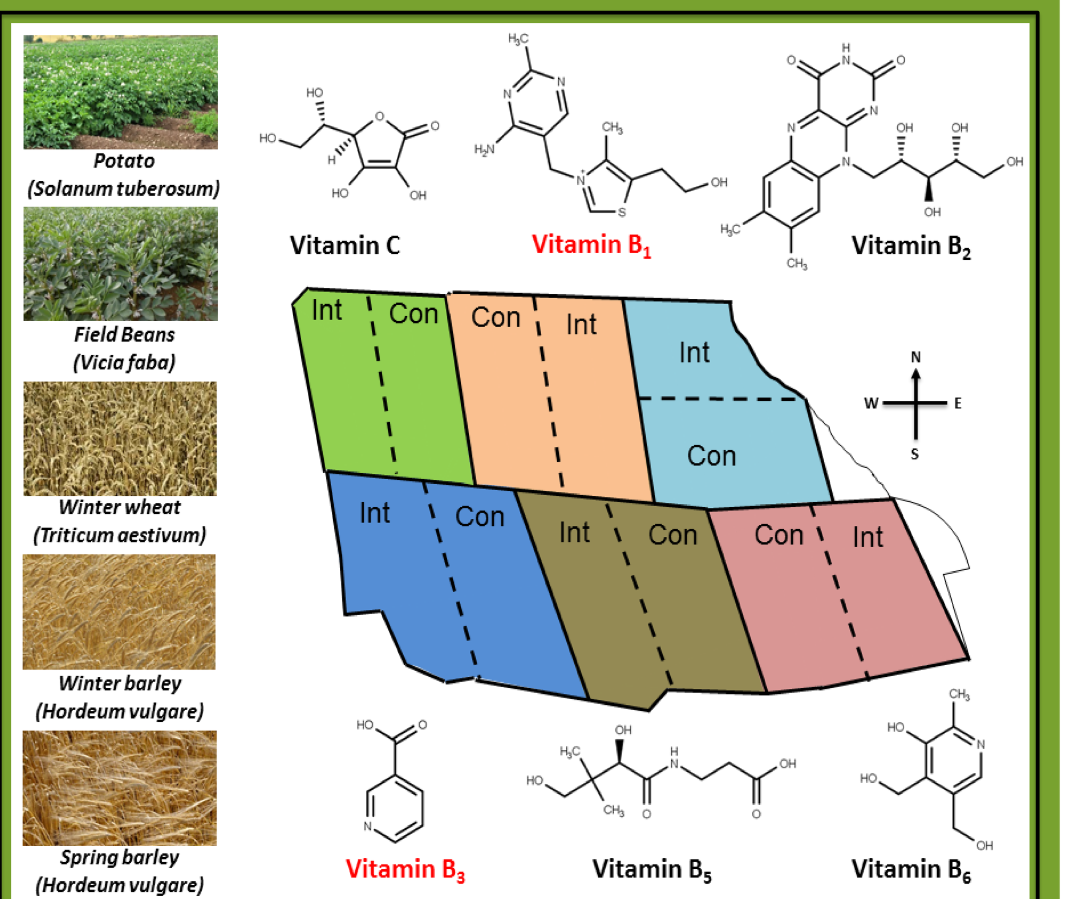

Figure 1. Experimental design, crops cultivated & vitamins quantified in the current project.

Methods

Sample material from five crops including potato (*Solanum tuberosum* L.), field beans (*Vicia faba* L.), Spring & Winter barley (*Hordeum vulgare* L.) & Winter wheat (*Triticum aestivum* L.), each with select varieties (each with five replicates, respectively), grown over five consecutive years (2011-2015) under two different management practices were extracted for B vitamin analysis, following the protocol from Nurit *et al.*(3). Chemical analysis of B vitamin content was performed on an Agilent 1260 HPLC system coupled to an Agilent 6460A Triple Quadrupole Mass Spectrometer (Agilent Technologies, Santa Clara, CA, USA). Vitamin C content of extracted potato samples was also determined on a High Performance Liquid Chromatography system coupled to a UV-Vis detector (HPLC, Dionex Ultimate 3000, Thermo Scientific). A separate statistical analysis was performed on $\log_{10}$ transformed quantitative data for each crop using **Re**stricted **M**aximum **L**ikelihood (REML) procedures in GenStat for Windows 17th edition.

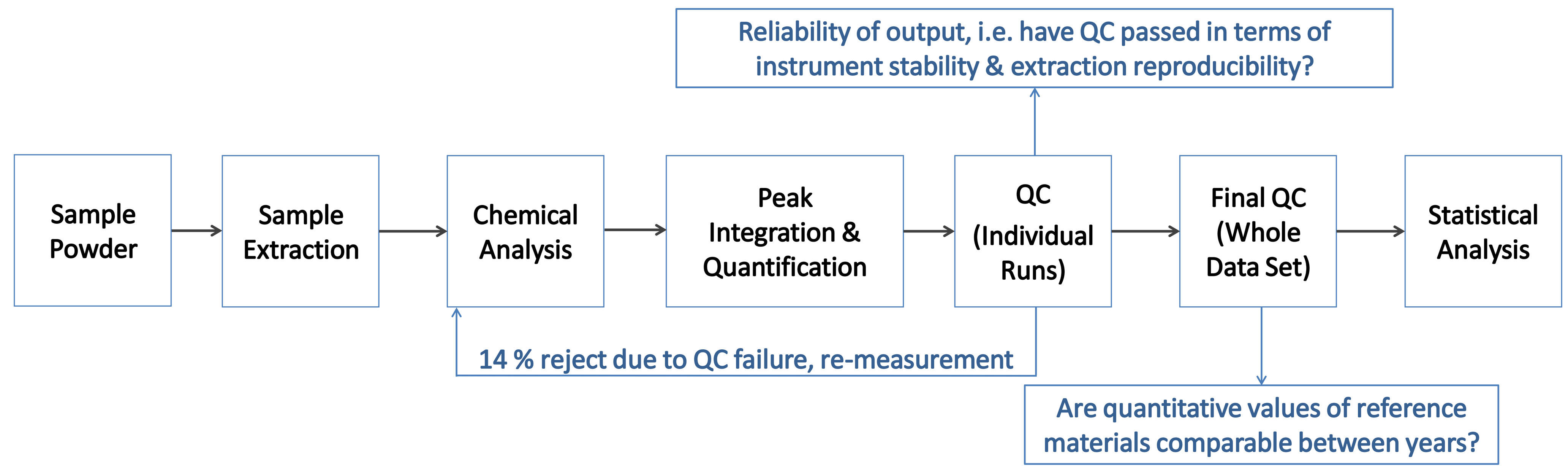

Figure 2. Schematic overview of experimental approach.

Results

- Potato had the highest concentration values in nicotinic acid, pantothenic acid, pyridoxine & riboflavin, followed by field beans (Figures 3A & 3B). Thiamine concentrations were in the same range.
- Our integrated, when compared with the conventional, management practice only had minor effects on vitamin content, but significant effects were observed for thiamine in field beans ($p < 0.01$), Spring barley ($p < 0.05$) & Winter wheat ($p < 0.05$). Nicotinic acid was also significant in Winter wheat ($p < 0.05$).
- However, for all crops, Variety & Year differences were generally of greater significance (Table 1).

Table 1. *p*-value overview of each crop for Variety, Input, Year, & the Interaction between Variety x Input.

Crop	Term	Nicotinic acid	Pantothenic acid	Pyridoxine	Riboflavin	Thiamine	Vitamin C
Potato	Variety	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001
	Input	0.969	0.278	0.486	0.246	0.112	0.443
	Year	0.056	0.012	0.773	0.007	0.001	0.021
	Variety x Input	0.608	0.663	0.588	0.315	0.368	0.608
Field Beans	Variety	0.038	0.074	0.002	< 0.001	0.051	
	Input	0.475	0.435	0.217	0.526	0.004	
	Year	0.002	0.059	0.011	0.090	0.008	
	Variety x Input	0.942	0.500	0.248	0.524	0.343	
Spring Barley	Variety	< 0.001	< 0.001	< 0.001	< 0.001	0.943	
	Input	0.745	0.553	0.103	0.853	0.033	
	Year	< 0.001	0.012	0.014	< 0.001	0.022	
	Variety x Input	0.830	0.298	0.348	0.556	0.606	
Winter Barley	Variety	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
	Input	0.373	0.769	0.337	0.675	0.054	
	Year	0.004	0.228	0.254	0.002	0.222	
	Variety x Input	0.190	0.671	0.353	0.754	0.928	
Winter Wheat	Variety	< 0.001	< 0.001	0.026	0.004	< 0.001	
	Input	0.046	0.869	0.109	0.057	0.029	
	Year	0.036	0.011	0.315	< 0.001	0.042	
	Variety x Input	0.321	0.602	0.547	0.802	0.533	

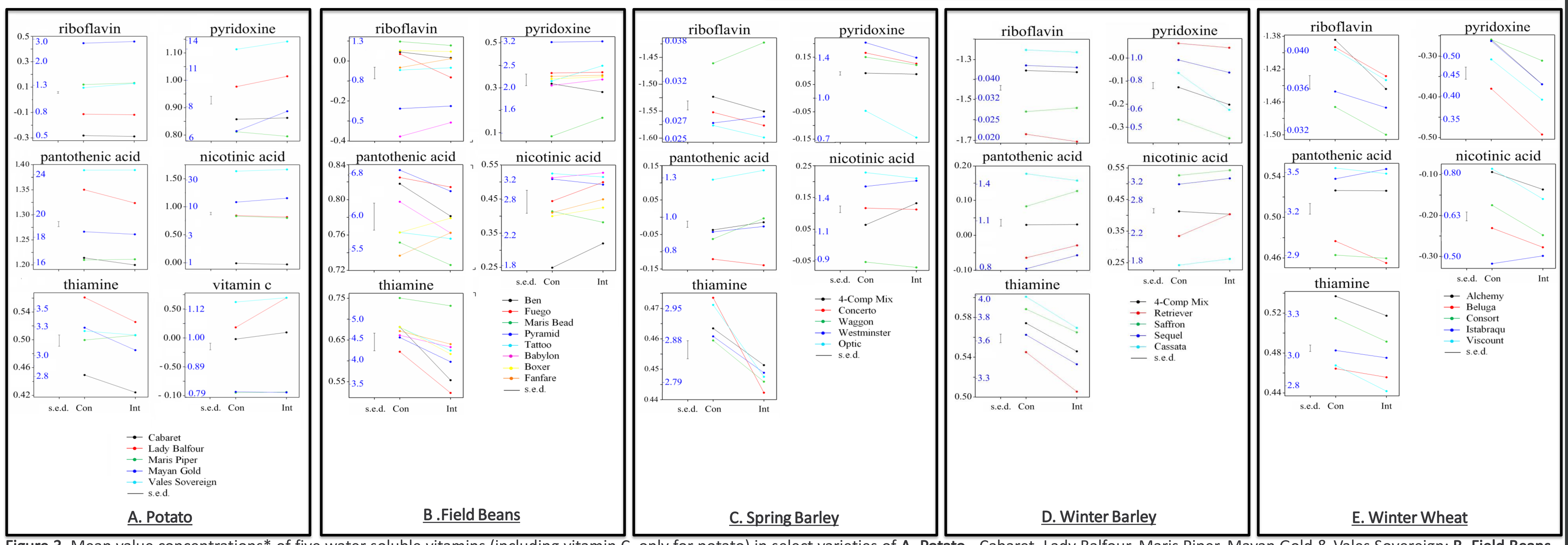

Figure 3. Mean value concentrations* of five water soluble vitamins (including vitamin C, only for potato) in select varieties of **A. Potato** - Cabaret, Lady Balfour, Maris Piper, Mayan Gold & Vales Sovereign; **B. Field Beans** - Ben, Fuego, Maris Bead, Pyramid, Tattoo, Babylon, Boxer & Fanfare; **C. Spring Barley** – 4-Comp Mix, Concerto, Waggon, Westminster & Optic; **D. Winter Barley** - 4-Comp Mix, Retriever, Saffron, Sequel, Cassata & **E. Winter Wheat** - Alchemy, Beluga, Consort, Istabraq & Viscount.
Where *= mean of five replicates per year x five years; 4-Comp Mix – 4-Component seed mixture; Con – Conventional; Int – Integrated.
Values are expressed on the logarithmically ($\log_{10}$) transformed (black values), & as mg kg^{-1} DW on the natural scale (blue values). The average standard of error of difference (s.e.d.) is for the Variety x Input term.

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Conclusions

- Results obtained in this study indicate that Input, i.e. our integrated management system, does not affect nutritional value in terms of water soluble vitamin content.
- Variety & Year differences were of greater importance.

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