Life cycle assessment for sustainable plant breeding: An example using porridge oats

Agriculture and food production systems are a major consumer of resources in the UK. The exploitation of plant variety traits offers a means to reduce the whole system impact on the environment and improves efficiency of resource use. In order to quantify the impact of different available variety traits a plough to plate life cycle assessment (LCA) of the flaked oat (*Avena sativa* L.) production chain was undertaken. The reduction of inputs which may be associated with multiple phenotypic characteristics was assessed using this technique.

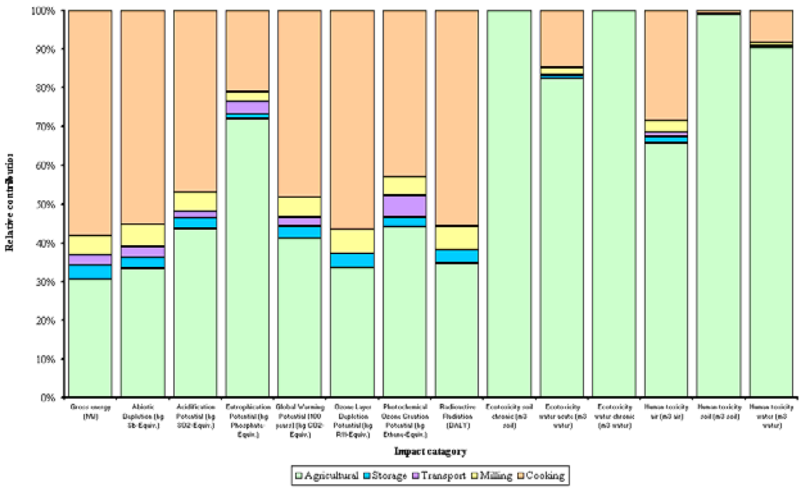

Figure 1, stacked bar chart showing the footprint of the porridge oats production chain on a number of impact categories.

It is clear from this study that plant varietal development can have a significant effect on the whole oat production chain. It was found that the agricultural component and the cooking process were the dominant resource consumers and producers of emissions in the oat production chain. An improvement in productivity per unit hectare would have the most substantial effect on reducing the ecological footprint of porridge oats. Although improvements in nitrogen use efficiency and cooking characteristics also confer a meaningful reduction of ecological footprint.

	Reduction in applied nitrogen	Reduction in applied phosphorus	Reduction in applied potassium	Reduction in cooking energy	Improvement in yield per hectare	Reduction in applied PGR	Reduction in applied insecticide	Reduction in applied fungicide	Reduction in applied herbicide
Gross energy (MJ)	-2.11	-0.37	-0.28	-5.29	-3.26	-0.03	-0.07	-0.12	-0.11
Abiotic Depletion (kg Sb-Equiv.)	-1.85	-0.33	-0.25	-4.64	-3.04	-0.03	-0.06	-0.10	-0.10
Acidification Potential (kg SO_2-Equiv.)	-3.12	-0.33	-0.25	-4.68	-3.96	-0.03	-0.06	-0.11	-0.10
Eutrophication Potential (kg P-Equiv.)	-5.63	-0.15	-0.11	-2.11	-6.56	-0.01	-0.03	-0.05	-0.04
Global Warming Potential$_{100\ years}$ (kg CO_2-Equiv.)	-2.70	-0.34	-0.26	-4.82	-3.74	-0.03	-0.06	-0.11	-0.10
Ozone Layer Depletion Potential (kg R11-Equiv.)	-2.26	-0.40	-0.31	-5.67	-3.07	-0.03	-0.07	-0.13	-0.12
Photochemical Ozone Creation Potential (kg Ethene-Equiv.)	-2.54	-0.30	-0.23	-4.29	-4.00	-0.03	-0.05	-0.10	-0.09
Radioactive Radiation (DALY)	-2.22	-0.39	-0.30	-5.58	-3.16	-0.03	-0.07	-0.13	-0.12
Ecotoxicity soil chronic (m^3 soil)	0.00	0.00	0.00	0.00	-9.09	0.00	-0.14	0.00	-9.86
Ecotoxicity water acute (m^3 water)	-0.59	-0.10	-0.08	-1.48	-7.49	-0.01	-0.02	-0.04	-0.04
Ecotoxicity water chronic (m^3 water)	0.00	0.00	0.00	0.00	-9.09	0.00	-10.00	0.00	0.00
Human toxicity air (m^3 air)	-1.98	-0.20	-0.15	-2.84	-5.97	-0.02	-0.04	-0.06	-0.06
Human toxicity soil (m^3 soil)	-0.08	-0.01	-0.01	-0.10	-8.99	0.00	-0.19	-0.05	0.00
Human toxicity water (m^3 water)	-0.33	-0.06	-0.04	-0.82	-8.21	-0.01	-5.07	-1.36	-0.02
Total	-25.40	-2.97	-2.29	-42.31	-79.63	-0.26	-15.92	-2.35	-10.76

Table 1, the percentage difference between a reference porridge oat production chain and an oat production chain with reduced resource input. The data relates to the effect of a 10% reduction in resource use through characteristics that may be affected by varietal development.

Few of the traits relevant to this study are immediately obvious and subject to phenotypic assessment. Therefore conventional hybridisation techniques and phenotypic selection may be unsuitable. Advances in molecular markers and other targeted DNA technologies that facilitate non phenotypic assessment could be utilised for this purpose. Therefore the integration of conventional ecophysiological and phenotypic profiling with targeted DNA strategies may be a strong methodology to produce varieties with enhanced characteristics relevant to sustainable consumption.

QUAKER OATS

defra

IBERS
Institute of Biological, Environmental and Rural Sciences

PRIFYSGOL ABERYSTWYTH UNIVERSITY

For more information contact:
James McDevitt
mpm@aber.ac.uk