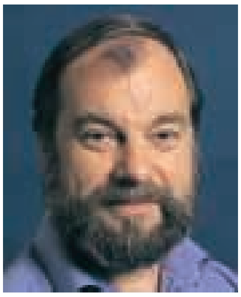
Beet and the Environment



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British Sugar Beet Review
Technical Article

The EU Sugar Regime is under review to decide the future of beet sugar production in Europe. The review will also consider the impact of sugar beet production on the European environment and in anticipation of this, the BBRO commissioned research to evaluate the direct environmental impacts of the activities used to produce a beet crop in England.

An important environmental benefit provided by sugar beet is its value as a break crop in rotations which are dominated by winter cereals. However, this was not the subject of our study. Nor did we examine the substantial benefits sugar beet offers birdlife, which are well documented by English Nature and the RSPB. Instead, we considered the effects of beet production on aspects of sustainability on animals living in and around the beet field, on the quality of the water draining through the field and on the air above. We considered economic sustainability, but not the sustainability of our use of the soil. This article describes the main findings of this study and includes some other aspects of soil quality.

Beet production methods

There is no single production method that adequately describes British beet agriculture. Therefore, we conducted this study with a range of production scenarios that, in large part, represent all of the current production systems. We set up 13 scenarios, each including a complete description of the soil type and the activities used to produce the crop. These represent peaty, silty, sandy and loamy soils, and for each of these we imposed appropriate manuring, soil cultivation, sowing, plant protection, irrigation and harvesting regimes. For completeness, we introduced an organic production scenario as well. From data recorded by British Sugar staff in the annual Beet Crop Survey we estimate that these scenarios accurately represented 92% of the UK beet area. Each scenario was assigned an average yield; these ranged from 34 to 60 t/ha. When these yields were weighted according the proportion of the nation's crop area that their scenarios represented, the average yield was 52 adjusted tonnes per hectare, which is within 0.5 t/ha of the UK three year average for 2000-2002. We assumed that 11% of the yield was 'C' beet in all scenarios except the organic production, where the whole crop was valued at the organic premium price.

Impact assessment methods

Clearly, we were not able to measure directly the impact of beet production in all 13 scenarios in representative parts of England and on all aspects of the environment. Instead, we used the best available mathematical models to predict these impacts.

- A model called pEMA (environmental management audit) was used to assess the effect of pesticides on animals and algae living in and around the fields, and the risk that the pesticides would leach into ground water.
- SUNDIAL was used to estimate amounts of N leached into drainage water.
- Spreadsheet techniques and recent publications were used to estimate energy consumption, CO_2 production and global warming potential.
- Net margin values were derived from real prices of beet and inputs, and from costs for farm operations published in Nix's Farm Management Pocketbook.

Environmental impact of pesticides

Pesticides are intended to have a direct impact on pest, disease and weed species. However, their use carries the risk that, even when used in accordance with conditions of approval (i.e. according to the label), they can harm other species too: pEMA assesses this risk in relation to algae, daphnia, earthworms, bees, fish, mammals and birds.

How relevant are these seven groups to beet growing? We assessed this crudely by surveying and classifying the habitat around beet fields. Using a video survey of about 650 randomly selected beet fields throughout the country, we classified two opposing boundaries of the fields into hedgerows, dry ditches, water filled dykes, woodland etc. The results of this classification are shown in **Fig. 1**. Because most beet is grown on well drained soil, very few beet fields have water on the boundary during summer and clearly this affects the risk that pesticides will harm fish. In England hedgerows are still the most common field boundary in beet growing areas.

Each time a pesticide was used in an environment where there was a moderate or high risk that it could damage any one of the seven types of creature listed above, the beet production scenario was awarded a score of five (moderate) or ten (high) toxicity points per creature. The scores ranged from zero (organic production) to 60 (sand land beet receiving Temik). The weighted average score of all production systems in the beet habitat was 26 **(Table 1).** This score will further improve when, for example, Temik is replaced in 2005. Ecotoxicity scores for other crops, made using the same techniques but in less detail, are also shown in **Table 1.** Clearly, if beet in the countryside is partly replaced by other arable crops, notably rape, peas or potatoes, the risk of harm to wildlife will increase.

Water quality

Of all the impacts of arable agriculture on water quality, two were considered in this study: the amounts of nitrate and pesticides in drainage water.

Table 1 – Pesticide ecotoxicity scores for a range of crops in the UK.

Crop	Score
Potatoes	230
Sugar beet[1]	26
Winter Wheat	35
Rape	85
Spring barley	30
Peas	75

[1] Sugar beet in its real, freely drained environment.

Compared to most arable crops, beet receives only small doses of mineral fertilizer, and for much of the season the crop grows by scavenging the soil for recently mineralised soil N. Therefore, after harvest, most beet fields (except those with organic peaty soil) contain little nitrate (20-30 kg N/ha). In this study the SUNDIAL model estimated that the crop would leave an average of 33 kgN/ha, of which 3 kgN/ha would leach. Studies on cereal crops show that their losses can often be 10-20 times larger than this.

None of the pesticides applied in any of the production scenarios was likely to leach into the drainage water in significant amounts. This finding agrees with the Environment Agency's monitoring of water quality, where sugar beet pesticides have never caused a breach of the Water Quality standards.

Energy consumption and global warming

The energy consumed by beet production in each of the 13 scenarios was calculated from published values for energy used in manufacture of inputs (seed, fertilisers, sprays etc); fuel used in cultivations, harvesting, transport etc;

Pic. 1 – Hedges and belts of tree are the most common boundary habitat around beet fields.

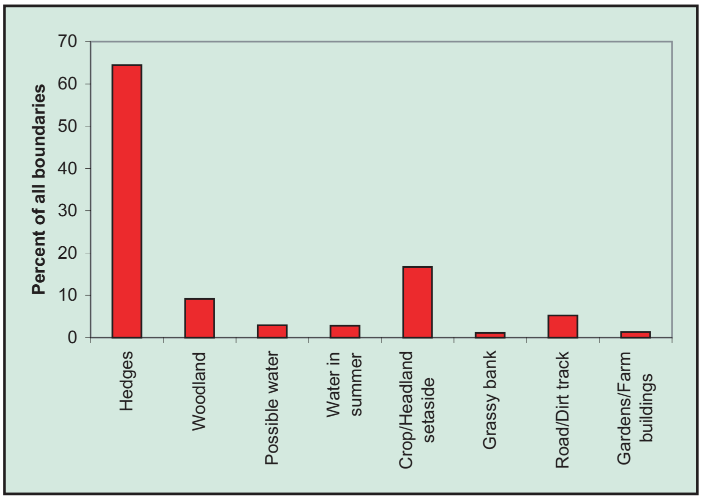

Fig. 1 – Boundary types adjacent to UK beet crops.

Table 2 – Energy inputs and GWP for producing one hectare of a range of crops in the UK.

Crop	Energy input * (GJ)	GWP (t CO_2 Eq)
Potatoes	31.3	3.0
Sugar beet	21.4	1.4
Winter Wheat	20.8	1.7
Rape	15.5	1.2
Spring barley	9.3	0.7
Peas	6.7	0.7

* All energy inputs are ex farm, except for sugar beet, which is as delivered to the factory.

and for energy used in the manufacture of machinery. Energy input is dominated by the amount needed to manufacture nitrogen fertilizer, so inputs ranged from 16 GJ (giga joules: giga means one thousand million and joule is an energy unit equivalent to a watt for a second) on organic soils which receive only small dressings of N up to 27 GJ on sandy soils that use 120 kg N/ha, plus irrigation. Because the beet crop only receives moderate doses of N compared to many other arable crops, its energy consumption is modest, despite the large weights of crop to be transported the average distance of 29 miles to the factory **(Table 2)**.

During crop production many 'greenhouse' gases are produced, and these have the potential to cause global warming (global warming potential, or 'GWP'). Gases like ammonia (from the degradation of plant debris) and nitrous oxide (from the breakdown of nitrate in the soil) can cause much more powerful warming effects than carbon dioxide (CO_2). Outputs of greenhouse gases have been estimated and expressed relative to their warming effect, as tonnes of CO_2 equivalent. For example, one tonne of nitrous oxide is equivalent to 310 tonnes of CO_2 because it can cause 310 times as much warming of our atmosphere. The GWP was estimated for all 13 production scenarios, and the weighted average value is shown in **Table 2**, compared to values calculated for other crops in the UK. Again, beet and wheat are similar, so there would be nothing to gain from a switch from one to the other. However, beet has the advantage that because of its high productivity, during growth it fixes approximately 35 t/ha of CO_2; wheat fixes much less. When expressed as global warming potential (GWP) per unit of output, beet therefore ranks very favourably compared to other arable crops.

Soil quality and conservation

Yields of most arable crops in England are rising, so there is little concrete evidence that soil quality is degrading on a large scale, although the simple act of soil cultivation inevitably oxidizes some soil organic matter so that it turns into CO_2 gas. However, on a local scale sugar beet has been associated with soil erosion. Some beet is grown on unstable sandy soils and the crop is slow to cover the ground with leaves. In these situations there is always a risk of erosion, by either wind or water. However, in recent years much has been done to stabilize the soil surface during the period between sowing and about the eight leaf stage of the crop. Practices like no-plough tillage and leaving crop debris on the surface, growing cereal cover crops, or stabilizing the soil surface with a press, have all reduced the occurrence of erosion so that no more than 500 ha (about one third of one percent of the national crop) have had to be redrilled because of erosion in any year since 1990. As a remit, yield losses due to erosion have never been more than slight.

In Europe there is serious concern about loss of soil as tare. For example, in France, soil tares have been three times greater than the UK but they are working hard to reduce this. In England the tare losses have averaged only 6.5% since 1995 and although this is clearly not an insignificant amount it represents only about 0.05% of the field top soil. In any case, the tare is not lost but is recycled for use in land reclamation, for landscaping and for soil improvement projects, as well as being repatriated back to arable land.

Economic sustainability

An important component of any assessment of environmental impact of agriculture is the effect of changes in production practices on each farmer's income and profitability. Profitability is determined by the integration of all the farm's enterprises and by the fixed costs, and so could not be determined in this study. Nevertheless, it is important to determine whether changes in production practices to improve the environment will allow the farm to continue to operate or will cause bankruptcy. We attempted to compare net margins, taking account of income, input costs and costs of operations like cultivating, spraying, harvesting and transport. All of our systems made a positive contribution to farm income, but this varied greatly, from £250 to £780 per hectare. Large margins tended to be associated with the largest yields and were not associated with the largest costs to the environment. However, it must be remembered that we were simulating the position with near average yields and were not taking account of fixed costs or land rental costs: in most cases the large yields will be produced on the highest value agricultural land.

Conclusions

The study described in this article shows that beet production in the UK consumes relatively small qualities of fertilisers and pesticides, and these inputs have been radically reduced in recent years. When expressed in terms of 'pesticide ecotoxicity' sugar beet has a more environmentally benign profile than other arable crops. Beet also has a beneficial role in helping to provide water quality, as it carries extremely low risk of leaching of either nitrogen or pesticides. It is a potentially valuable source of biomass (e.g. for renewable fuel) as it has a high ratio of biomass (e.g. for renewable fuel) as it has a high ratio of biomass output per unit of input (and CO_2). In terms of soil conservation, the effects of wind erosion have mostly been solved and soil lost as tare is recycled and used in a variety of productive applications. Added to this, beet is an important break crop providing diversity of habitat in the arable landscape and offers substantial benefits for birds.■

Acknowledgement

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