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CASE STUDY BOOKLET

Biomass for a Brickworks

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Summary

This case study features the planting of two varieties of black locust (*Robinia pseudoacacia*), a fast-growing tree species not normally cultivated in the UK. This pioneering trial is being undertaken on agricultural land owned by H.G. Matthews, a traditional brickmakers[1] located in Buckinghamshire, which burns large quantities of locally sourced wood in boilers and kilns for drying and firing bricks. Prompted by the rising cost of their fuel, concerns over potential future shortages of wood and the eventual expiration of its current Renewable Heat Incentive agreement, the business is investigating whether it can become self-sufficient in fuel. There is also potential for a new revenue stream for H.G. Matthews based on timber sales, since one of the two cultivars of black locust being trialled can yield high quality hardwood.

Background

Established in 1923 in the Chilterns area of Buckinghamshire (north west of London), H.G. Matthews manufactures traditional wood-fired bricks for conservation/restoration and high-end new build markets. In the 1940s, the family started farming arable crops on 260 hectares of land close to the brickworks. More recently, the company diversified into ecological building materials such as manufactured natural blocks called 'strocks', containing straw grown on the farm. The company employs 55 people across its brick-making and agricultural businesses.

Figure 1: Drying and firing of bricks

Bricks are made primarily of clay and sand; prior to firing, the wet, moulded bricks need to be dried. Traditionally they were laid outside to dry in the sun between April and September but since the 1940s H.G. Matthews has dried the bricks indoors in a heated room, enabling year-round production. Heat was initially provided by a coal-fired steam boiler, later modernised to burn oil, with some 30,000 litres of diesel consumed per month for drying the bricks. In 2009, as the diesel boiler was reaching the end of its life, the company replaced it with a 600 kW biomass boiler (motivated by the high prevailing oil price and in anticipation of a growth in demand for low-carbon bricks). The investment proved unsatisfactory (the heat-exchanger failed and the boiler underperformed in terms of heat production), but in 2012 the company was encouraged by the recently introduced Renewable Heat Incentive (RHI) to double-down on biomass, this time purchasing four 199 kW boilers at a total cost of approximately £400,000. Under RHI regulations each boiler required a dedicated wood chip storage bunker. To save costs, four redundant 25-tonne grain bins were repurposed to serve as bunkers.

Around 2,000 tonnes per annum of cord wood is sourced primarily from within 25 miles of the farm, the surrounding Chilterns countryside among the most heavily wooded areas of southern England. Approximately two-thirds of this purchased fuel is softwood (e.g. larch, pine) which is chipped and burnt in the biomass boilers. The company hires a

Figure 2: Chipped wood used to feed biomass boilers being fed into the hopper

chipper every 6 weeks to produce 30 to 40mm diameter chips. Renting a chipper was deemed more economic than purchasing with the outlay on a chipper being as much as £500,000, excluding regular maintenance and insurance, whereas hiring costs just a few thousand pounds each time. The remainder of the purchased fuel is hardwood (e.g. beech, ash), burnt in the kilns used for firing the bricks. This kiln wood is not chipped but mechanically cut into 'extra-large' 45 cm logs, then fed manually into the kilns by two people working 12-hour shifts and working 28 fireholes. Batches of 60,000 bricks are fired at a time.

Since 2009, timber costs have risen from approximately £25 per tonne to as much as £90 per tonne (of unchipped cord wood), a trend that may reflect increased demand for biomass energy, compounded by recent restrictions in global timber stocks (resulting from the war in Ukraine). Biomass energy is therefore today only viable for H.G. Matthews thanks to the RHI subsidy. However, the 20-year RHI agreement is due to expire in 2032 with the scheme now closed to new entrants. While it is possible that the low-carbon bricks manufactured by H.G. Matthews may attract a premium by then (economically justifying the continued use of biomass energy), this is by no means certain – nor indeed is future availability of local wood. Therefore, Managing Director Mr Jim Matthews recently began exploring the option of growing their own biomass crop to maintain use of the biomass boilers in the face of rising energy costs and the loss of the RHI subsidy, and to secure a fuel supply.

Introducing black locust

Mr Matthews decided not to grow biomass species typically grown in the UK, such as willow, poplar and Miscanthus, because of his understanding of the demands of the brick kilns. He considered the financial (and energy) costs of drying and storing such crops prior to combustion were likely to outweigh any projected benefits. Instead, Mr Matthews decided to try growing the black locust tree as a promising alternative. He had learned

about the species during a Biomass Connect demonstration event at the premises of Biomass Connect partner Bio Global Industries Ltd (BGI), which by chance are located just one kilometre from the brickworks.

Black locust (*Robinia pseudoacacia*), sometimes known as 'false acacia', is a medium-sized hardwood deciduous nitrogen-fixing tree, native to the Appalachian mountains of the southern United States. Prized for its rapid growth and for the high calorific value and naturally low moisture content of its wood, black locust is today widely planted around the world for both lumber and energy production. As a nitrogen-fixing tree, black locust can also enrich impoverished soils and it was partly for this reason that the species has been widely planted in previously degraded and sandy soils in eastern Europe since the early 1700s (today, 25% of all forests in Hungary are made up of black locust). More information on black locust is available on the Biomass Connect website[2].

Mr Matthews decided to plant two cultivars of black locust (developed by Silvanus Forestry[3] in Hungary), each with a different intended application:

Black Locust Turbo – for fuel

Black locust Turbo seedlings were planted as an experimental short-rotation biomass crop ready for initial harvesting after two or three years. Mr Matthews plans to use the larger stems and branches of harvested black locust as well as the brash. All of this will be chipped for the biomass boilers. As in the wild, the black locust Turbo cultivar is a multi-stemmed tree and easily coppiced, suggesting its suitability for biomass applications. However, this will be one of the first times the species will be grown and chipped for this purpose (in Eastern Europe the tree is used for firewood logs only).

Black Locust Turbo Obelisk – for agroforestry

Black locust Turbo Obelisk saplings were planted as a silvo-arable agroforestry crop, in other words, a single area of land managed to produce both timber and arable crops. In this case, H.G. Matthews intends to interplant wheat and barley in the agroforestry plantation. Black locust roots are proficient nitrogen fixers, providing natural fertilisers to the soil. This will likely start benefiting the arable crops within three or four years, reducing the need for artificial inputs. Black locust Turbo Obelisk has been bred over the last 30 years to produce a single, straight trunk, making this cultivar ideal for timber production. It should be noted, however, that black locust's performance in the UK is still poorly understood – so the results of Mr Matthews's trial will be keenly watched.

When mature, the black locust crowns will be used at the brickworks for biomass burning. The cordwood meanwhile will either be used in H.G. Matthews's kilns or more likely sold as construction timber to meet a growing demand for locally grown construction materials. The proceeds from these sales could be used to purchase cheaper wood for the kilns. Another marketable product (within 8 to 9 years of planting) is post and rail manufacturing, particularly because of the high tannin content of all black locust wood. This in-built natural preservative provides longevity in microbially active environments, reducing the need for artificial treatments (even with such treatments, traditional post and rails tend not to last more than three or four years in UK soils with a high microbial count).

Environmental Impact Assessment

Prior to planting, an environmental impact assessment (EIA) was required by Forestry Commission England. This was because the area of Mr Matthews's farm initially proposed to be planted (approximately 5.9 hectares) exceeded the threshold set out in Forestry Commission guidance on 'projects likely to have significant effects on the environment[4]' and was sited within an Area of Outstanding Natural Beauty (AONB) (in this case, the Chilterns AONB).

Environmental conditions for black locust

Black locust grows across a range of climates and soils, and is generally drought-tolerant, though particular conditions are favourable for successful development[5].

- Grows well where mean annual temperatures are over 8°C
- Can grow in regions with as little as 500 mm annual precipitation
- Late and early frosts, as well as low winter temperatures, can be damaging
- Tolerates diverse pH from 3.2 to 8.8
- Tolerates dry and nutrient poor soils, but grows best on deep, nutrient-rich, moist, uncompacted, well-drained light soils (silt loams, sandy loams, or sandy soils)
- Rendzinas, calcium-carbonated soils in the upper horizons, poorly drained and highly compacted (clayey) soils, very dry as well as hydromorphic soils with gley or pseudogley, are not suitable
- The groundwater table should be deeper than 150 cm as nitrogen fixing bacteria of black locust are inhibited by high water table and periods of flooding

The EIA application required the following:

- A full constraints check for any priority habitat, sensitive soils, designated areas and public access rights.
- Environmental screening for landscape character, erosion and flooding.
- A lifecycle proposal with consideration given to what the future land use intention or 'end of life' will be.
- A landscape context plan of the proposed site and local landscape features.
- Detail of management objectives.
- Stakeholder engagement with an accompanying issues log.
- A desk and field survey of the site to establish any vulnerabilities, threats, access issues and utility infrastructure.
- Historic Environment and National Character profile report.
- Evidence of the proposal adhering to UKFS forest design principles.

In October 2023 an environmental consultant was commissioned to carry out the EIA. In the event, different, far smaller pieces of land on the H.G. Matthews farm were planted with black locust (as detailed below). This led to a confirmation in March 2024 that the proposal would not in fact require Forestry Commission consent under the EIA regulations, a decision valid for 5 years. The change of plan occurred after H.G. Matthews was incentivised by a UK Government scheme to use the larger area of land for wildflower meadows instead. The scheme, AB8: Flower-rich margins and plots[6], pays land managers £798 per hectare planted with wildflowers.

Planting

On 11 April 2024 the black locust saplings of both cultivars were delivered as bare roots from Silvanus Forestry, Hungary, and planted the following day. The planting, in an area west of the brickworks, was in relatively small parcels for the purposes of research and development, with the intention to scale up both crops should these initial experimental plantings be successful. Prior to planting, a cover crop of winter wheat had been sown on the land selected for the black locust, to suppress weeds and aerate the soil.

Planting of the two black locust cultivars was undertaken as follows:

Black locust Turbo – for SRC biomass for fuel

Some 4,320 black locust Turbo saplings were planted 0.8 m apart in SW to NE rows following the orientation of the field across 0.72 ha, equating to a density of 6,000 stems per hectare. This relatively dense planting is intended to maximise the biomass for short rotation coppicing. Space was allowed at the end of rows for machinery movement (header racks). Given the need to plant a large number of bare roots as quickly as possible, existing farm machinery - specifically a vintage Danish cable-trenching machine and a Christmas tree-planter - was repurposed to the task of planting. Elsewhere in the Chilterns, a region whose soil is known for a high flint content, a mechanical approach of this type would have been impractical; however, the soil at H.G. Matthews farm is unusually low in flint and the planting was completed in a single day without mishap. The Christmas tree-planter was used for around three-quarters of the saplings, and the trencher for the rest. Although planting with the trencher is slower, it provides a good tilth and friable root bed, which may potentially result in a better quality crop.

Black locust Turbo Obelisk - for agroforestry

Shortly after the black locust Turbo planting, 200 micropropagated saplings of black locust Turbo Obelisk were planted across 0.75 ha in holes hand-dug using a spade to a depth of about 20 cm. The rows were planted in a north-south orientation to allow as much sunlight as possible to the crops between the rows, with 15 m spacings between them. The choice of spacing sought to maximise the number of trees planted in a given area, while enabling access to standard agricultural equipment (e.g. tractors, medium-sized combine-harvesters, etc.). Within the rows the trees were planted at 3 m intervals.

Figure 4: Growth on black locust sapling planted as Short Rotation Coppice

Crop management, monitoring and harvesting

Directly after planting all saplings were cut off to ground level. This practice enables the root system to develop in advance of the stem, providing a robust anchor for the growing crop. New above-ground growth is expected within three months of planting. In autumn, both the biomass and agroforestry crops are monitored for failures, with any gaps filled in with additional root stock.

Mr Matthews intends to manage the two recently planted crops in different ways:

Management of black locust Turbo – for SRC biomass fuel

For protecting the black locust Turbo saplings from wild grazers, a 2 metre-high deer fence was erected in May 2024 around the planted area at a cost of £5,000. Mr Matthews intends to maximise the benefits of the enclosure by also introducing chickens. Initially, due to the legislative hurdles of farming chickens commercially, the eggs from a small flock of perhaps 50 birds will be distributed freely to brickworks employees. The chickens, which offer the additional potential benefits of fertilising the trees through their droppings and controlling invertebrate pests, get introduced to the enclosure when the trees are established after six to eight months. If the biomass experiment proves a success and the black locust Turbo is planted over a wider area, Mr Matthews may switch to selling the eggs commercially.

Weights and height measurements of the biomass crop will be taken after two years to assess survival and viability, and to estimate total biomass. The relative performance of trees planted with the trencher and Christmas tree-planter will also be assessed. At this point, an initial harvesting may be warranted, potentially using an adapted forage harvester, with direct chipping on the field. Should an additional 12 months' growth be required, harvesting will likely be undertaken using small-scale agroforestry machinery with grabs and blades mounted on a platform. The harvested material will be cut, stacked and then chipped prior to use in the biomass boilers. As noted, a significant benefit of using black locust as a biomass energy source, is its low moisture content at harvest, obviating the need for expensive drying and storage prior to use.

Management of black locust Turbo Obelisk - for agroforestry

Due to the cost, the agroforestry crop was not fenced but instead protected using plastic tree guards which Mr Matthews had on hand. As discussed below, he is considering using biodegradable tree guards for future plantings. When sapling height reaches 1 metre, potentially after 3 or 4 months, a spray-on lanolin treatment can be administered to the leaves to deter deer. The agroforestry crop is then monitored approximately every two weeks to assess the efficacy of these measures in protecting saplings from grazers. A small amount of pruning is needed for the agroforestry crop to ensure a straight trunk, with any small branches removed off once or twice annually. The black locust Turbo Obelisk in the agroforestry planting will be harvested manually using chainsaws.

Figure 5: Row of planted black locust Turbo Obelisk in tree guards in agroforestry trial

Challenges

Non-native status and invasiveness potential of black locust

A key challenge with black locust is its reputation as an invasive species. Some experts assert that the risks are exaggerated, arguing that the tree is a pioneer species requiring high light levels and therefore poorly equipped to invade and outcompete native species in mature woodlands with closed canopies. Furthermore, black locust seed germination requires fire exposure. Nevertheless, the non-native status of the black locust was of particular concern to Forestry Commission officials, who pointed to the proximity of the proposed planting site to priority deciduous woodland habitat where biodiversity planting native deciduous woodland is encouraged. Moreover, the Forestry Commission would normally class the proposed planting density of the agroforestry crop of approximately 267 trees of a single species per hectare as 'woodland' and therefore requiring their consent (the usual threshold is 100 trees per hectare). In the event, due to the small scale of the planting project, Forestry Commission consent was not required under the EIA regulations. Should Mr Matthews decide to expand his black locust crop, he may propose using a mixture of species to overcome this issue.

Absence of domestic nursery for black locust

Despite black locust being among the world's most widely planted trees, no nursery source for black locust in the UK currently exists. As a result, anyone wishing to plant black locust in the UK must import: under current phytosanitary regulations, any living plant material sourced from a European Union Member State cannot be delivered to the UK in soil plugs, but rather must be delivered as bare root stock with an extremely limited shelf-life of three days or fewer. Fortunately, the Brickwork's saplings were shipped and delivered from Hungary within 24 hours.

Lack of EIA consultants

The detailed requirements of the EIA initially required by the Forestry Commission presented a further challenge: finding a consultant sufficiently qualified to address these issues proved to be a struggle, with more than 10 individuals and firms approached before one was eventually commissioned to undertake the work. By the time it was confirmed an EIA was in fact unnecessary and approval granted for the project, the ideal period for tree planting in the UK (typically, October to March) had almost passed. With little time left, Mr Matthews had to move quickly.

Grazing pressures

Another important consideration is the need to protect saplings from grazers. Due to the high sugar content of its shoots and leaves black locust is especially vulnerable to rabbit and deer. Typically, fencing is used, such as in large plantations in Eastern Europe, and this was installed by H.G. Matthews for the black locust Turbo SRC biomass crop. However, fencing off large areas is expensive. Therefore, as noted, reused tree guards were used to protect the black locust Turbo Obelisk agroforestry crop, followed by lanolin treatments. Mr Matthews had considered using biodegradable fence guards. Such tree guards are designed to decompose over time, steadily releasing into the soil nutrients which are required by the growing black locust saplings, while avoiding plastic waste in the landscape. He decided that these were not yet economically viable but may be used in the future should the agroforestry crop be expanded.

Establishment and management costs

H.G. Matthews has entirely self-funded the black locust trial, which to date has cost in the region of £15,500, as detailed in the below table:

	Price/unit	Units	Price	VAT	Price inc. VAT
Turbo Seedlings	£0.76	4,350	£3,306	£661	£3,967
Turbo Obelisk	£4.00	200	£800	£160	£960
Shipping of seedlings and saplings	£693.02	1	£693	£139	£832
Customs Clearance Certificate	£85.00	1	£85	£17	£102
EIA consultant costs (indicative)*	£3,000.00	1	£3,000	£600	£3,600
Deer fence (Turbo biomass crop)	£5,000.00	1	£5,000	£1,000	£6,000
			£12,884	**£2,577**	**£15,461**

*In other situations, the EIA consultant costs could have been significantly lower or even not needed at all; however, these are included as they reflect the actual costs paid by H.G. Matthews in this case.

Going forward, Mr Matthews expects to pay annual costs of approximately £1,500 for managing and harvesting the biomass crop, and £1,000 for the agroforestry crop for this experimental planting. There are also estimated opportunity costs, in terms of lost wheat and barley yield from the biomass plot, of about three tonnes per year, worth £500 at current prices, according to Mr. Matthews. For the agroforestry plot, lost arable crop yield is around 0.5 tonnes/year (£80-90 based on 2024 prices) – however, in later years Mr Matthews expects to recoup some of this given the assumed boost to crop yield from the black locust nitrogen-fixing.

As a novel biomass crop in the UK, the Biomass Connect project will be following the outcomes of this trial with great interest.

References

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4: https://www.gov.uk/guidance/environmental-impact-assessments-for-woodland

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6: https://www.gov.uk/countryside-stewardship-grants/flower-rich-margins-and-plots-ab8

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