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Barriers and incentives to the production of bioethanol from cereal straw: A farm business perspective

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HIGHLIGHTS

- English arable farmer survey to determine potential supply for straw based biofuel.
- Two-thirds of farmers would supply wheat straw for bioenergy.
- Farmers willing to sell 1.65 Mt of cereal straw from the main cereal producing regions.
- Farmer preference for a fixed area of straw supply for a contracted fixed price.
- £50 t^{-1} the most frequently cited minimum contract price farmers find acceptable.

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ABSTRACT

The EU renewable energy directive stipulates a requirement for 10% of transport fuels to be derived from renewable sources by 2020. Second generation biofuels offer potential to contribute towards this target with cereal straw representing a potentially large feedstock source. From an on-farm survey of 240 arable farmers, timeliness of crop establishment and benefits of nutrient retention from straw incorporation were cited as reasons for straw incorporation. However, two-thirds (one-third) of farmers would supply wheat (barley) straw for bioenergy. The most popular contract length and continuous length of straw supply was either 1 or 3 years. Contracts stipulating a fixed area of straw supply for a fixed price were the most frequently cited preferences, with £50 t^{-1} the most frequently cited minimum contract price that farmers would find acceptable. Arable farmers in England would be willing to sell 2.52 Mt of cereal straw for bioenergy purposes nationally and 1.65 Mt in the main cereal growing areas of Eastern England. Cereal straw would be diverted from current markets or on-farm uses and from straw currently incorporated into soil. Policy interventions may be required to incentivise farmers to engage in this market, but food and fuel policies must increasingly be integrated to meet societal goals.

1. Introduction

As part of the drive to increase renewable energy use within Europe, the EU has set a revised target for 10% of total transport fuels to be derived from renewable sources by 2020 [EU, Directive 2009/28/EU]. In the UK, the main renewable transport fuels are biodiesel and bioethanol; much of the bioethanol is imported and derived from 'first generation' technologies (Bomb et al., 2007). The UK has implemented a range of policies to support renewable energy (see, for example, Mitchell and Connor, 2004) and more recently funding has been made available for research into 'second generation' fuel technologies (Anon, 2012a) i.e. those not based on crop products that have an alternative use as food for direct (or indirect) human consumption. As part of this research focus on second generation fuels, the Biotechnology & Biological Sciences Research Council (BBSRC) established 'BSBEC', the BBSRC Sustainable BioEnergy Centre (Anon, 2012b). Work within the Centre includes research into the lignocellulosic conversion of cereal straw into bioethanol. Bioethanol from this agricultural residue feedstock, as a 'co-product second generation biofuel' (CPSGB; Glithero et al., 2012), mitigates some of the concerns that have been raised in relation to land use change, as the use of a co-product does not compete directly with food production (Londo et al., 2010; Naik et al., 2010; Nigam and Singh, 2011; Williams, 2008). However, while some authors have argued that straw

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should be used as a replacement for fossil fuels in bioenergy production more generally (e.g. Gabrielle and Gagnaire, 2008), others have raised 'sustainability' concerns (Thornley et al., 2009); these include the potential depletion of soil organic matter if straw is not incorporated into the soil (Cherubinia and Ulgiatib, 2010; Lal, 2008). Set against this, it is worth noting that, before the UK straw and stubble burning ban of 1993, up to 41% of wheat straw in England and Wales was burnt in the field (Silgram and Chambers, 2002).

It has been estimated that on arable farm types in England 3.82 Mt of cereal straw (from wheat and barley) is currently used on-farm or sold, with a further 1.45 Mt chopped and incorporated into the soil (Glithero et al., in press). Another estimate puts the 'straw surplus' (from cereal crops chopped and incorporated), in Great Britain, from all farm types, at 5.7 Mt in 2007 (Copeland and Turley, 2008). In the UK, the Ely Combined Heat and Power plant (270 GWh plant) uses 200 kt of straw per annum and describes itself as the largest straw burning plant in the world (Anon, 2012c); in other countries considerable interest in using straw as an energy source is developing (Skött, 2011). The UK bioenergy strategy (Anon, 2012a) noted that in 2009 approximately 3% of UK cereals were converted into biofuels, using mainly first generation technology, generating 0.6 TWh of energy. The strategy also suggests that the 'tradable surplus' of UK cereals could be used for bioenergy production and that domestic supply of bioenergy feedstocks could produce over 75 TWh of energy from agricultural residues such as straw and dedicated biomass crops such as short rotation coppice (SRC) and miscanthus, as well as other biomass sources (e.g. managed woodland). Despite these positive estimates of feedstock supply for second generation technologies, a number of barriers to their use for bioenergy remain. We briefly consider the latter, below.

The potential reluctance of farmers to displace conventional cropping with dedicated energy crops has been noted by Convery et al., 2012. Although CPSGBs such as cereal straw do not lead to crop substitution, the co-products do have many alternative end uses. These include: animal bedding (Wolf et al., 2010), animal feed (Copeland and Turley, 2008), on-farm production of other crops (Döring et al., 2005), industry (such as burning for energy; Anon, 2004), crafts, such as thatching (Yates, 2006), building materials (Swanston and Newton, 2005), export (Tasker, 2011), and incorporation into soils providing potential soil organic matter enhancements and some nutrient supply to the following crop (Anon, 2010; Nicholson et al., 1997; Powlson et al., 2011). Of these, the majority of straw is used in livestock production or is incorporated. Additional barriers to the use of straw for bioethanol, beyond its current uses, are the costs and difficulty of storage and transportation over long distances (Swanston and Newton, 2005). Despite the wide range of potential end uses, a substantial proportion of straw in the UK, particularly in areas that are distant from livestock production, is currently chopped and incorporated. A major benefit of straw incorporation is improved timeliness of farm operations: incorporation allows more prompt establishment of the following crop (Darby and Yeoman, 1994). Machinery, storage and labour costs are also lower. As noted, straw incorporation has also been linked to improved soil organic matter levels in soils; indeed, the UK Code of Good Agricultural Practice (Anon, 2009a) states that: '*Incorporating crop residues that do not contain much nitrogen, such as cereal straw, into the soil in autumn will help to reduce the amount of nitrate leached and to maintain or increase soil organic matter*'.

Mitchell and Connor (2004) note bioenergy policy incentives at both industrial and feedstock supply levels and suggest that there is substantial potential for energy crops and agricultural waste products to be used in energy production in the UK. However, no UK or EU-wide policies related to straw removal for bioethanol or bioenergy purposes currently exist, which is in direct contrast with dedicated energy crops such as SRC and miscanthus, where, for example, the 'Energy Crops Scheme' (Anon, 2009b) in England provides crop establishment funding for SRC and miscanthus, albeit that several authors have also identified barriers towards dedicated energy crop uptake (Piterou et al., 2008; Sherrington et al., 2008; Sherrington and Moran, 2010; Alexander et al., 2011; McCormick and Kåberger, 2007).

Farmer decision making in relation to crop or enterprise choice and business activities is influenced by a wide range of factors (Edwards-Jones, 2006). Whilst historically farmers have been partially protected against the vagaries of the open market, through national and European support mechanisms (Gorton et al., 2008), they now operate in a much freer market environment, with attendant risks and opportunities, responding to market signals (Lobley and Butler, 2010). Cereal farmers can manage this environment, to an extent, by marketing their grain using a range of methods: forward contracts (an agreed price, quality and date for future sale), sale and purchase of futures contracts to hedge against falling prices, and 'options' which allow, at a premium, a farmer to both hedge against grain price falls and take advantage of upside market opportunities. Alternatively they may market all or some of their grain on the open 'spot' market.

Cereal straw is typically marketed on the spot market, via auctions or private sales and additionally as baled produce, 'sold-in-swath' (sold to a third party straw harvesting and transportation contractor or other farmer undertaking these functions)[1] or sold as a standing crop. However, for bioenergy purposes, where large scale investment is needed on behalf of fuel producers, securing sufficient supply in a defined geographical region is likely to require contractual agreements with farmers, perhaps similar to those used for grain, to secure feedstock supply; currently there is no information on the characterisation of such contracts that farmers would find acceptable, nor the volume of straw that will potentially be supplied.

It is clear that, although cereal straw is a 'co-product', it has a range of potential benefits in its current uses, both as an end product and when incorporated into agricultural soils. The focus of the remainder of this paper is therefore an assessment of cereal straw supply for bioenergy production examining the barriers that exist at the farm-level with respect to supply of straw for bioenergy, as well as the incentives required to establish a sustainable feedstock supply base. The aim of the paper is to (a) describe the survey methodology used, (b) estimate the amount of straw that farmers would sell for bioenergy purposes, (c) indicate the number of years that farmers would supply straw and, in addition, the contractual aspects of supplying straw for bioenergy production that farmers would find acceptable, (d) illustrate potential barriers to feedstock supply for bioenergy in relation to straw, (e) examine regional logistic aspects of feedstock supply and (f) place these survey findings in the context of CPSGBs. The survey methodology is outlined in Section 2 along with the data analysis methods employed within the paper. The survey results in relation to contracts, amounts of straw and potential barriers to supply are presented in Section 3. Discussion of the survey findings in relation to bioenergy and in particular CPSGBs is given in Section 4 with concluding remarks in Section 5.

[1] Specifically, sold-in-swath refers to straw sales where the straw purchaser undertakes to bale and removes the straw from the field directly following the harvest of the crop from which the straw is left in rows (swaths) in the field. This is in contrast to the farmer baling the straw and selling the produce as a baled commodity.